Grades 9-12 Science
Physics

One Dimensional Kinematics

Stage 1: Desired Results

Catholic Standards

DOC All Grades DOC: Catholic Standards

The Profession of Faith

Students will be able to

1. Recognize God in the world's order, beauty, and goodness (CCC 32).

Life in Christ

Students will be able to

2. Know that we must assume responsibility for the acts we perform (CCC 1781).

7. Assume personal responsibility (CCC 1914).

12. Respect the integrity of all creation, including animals, plants, and all nature (CCC 2415).

Targeted Standards

NGSS Grade 9-12 NGSS: Crosscutting Concepts

Crosscutting Statements

Patterns Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

NGSS Grade 9-12 NGSS: Science and Engineering Practices

Practice 8. Obtaining, evaluating, and communicating information

Obtaining, evaluating, and communicating information in 912 builds on K8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.

Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Practice 6. Constructing explanations (for science) and designing solutions (for engineering)

Constructing explanations and designing solutions in 912 builds on K8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.

Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Practice 7. Engaging in argument from evidence

Engaging in argument from evidence in 912 builds on K8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.

Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Practice 1. Asking questions (for science) and defining problems (for engineering)

Asking questions and defining problems in 912 builds on K8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.

Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.

Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.

Ask questions to clarify and refine a model, an explanation, or an engineering problem.

Evaluate a question to determine if it is testable and relevant.

Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.

Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.

Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and/or environmental considerations.

Practice 2. Developing and using models

Modeling in 912 builds on K8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria.

Design a test of a model to ascertain its reliability.

Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.

Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Practice 3. Planning and carrying out investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigations design to ensure variables are controlled.

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.

Select appropriate tools to collect, record, analyze, and evaluate data.

Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.

Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

Practice 4. Analyzing and interpreting data

Analyzing data in 912 builds on K8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.

Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.

Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.

Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.

Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Practice 5. Using mathematics and computational thinking

Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Apply techniques of algebra and functions to represent and solve scientific and engineering problems.

Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model makes sense by comparing the outcomes with what is known about the real world.

Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).

OH Grade 9-12 OH: Science (2011)

HS Physics

Science Inquiry and Application During the years of grades 9 through 12 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

Identify questions and concepts that guide scientific investigations;

Design and conduct scientific investigations;

Use technology and mathematics to improve investigations and communications;

Formulate and revise explanations and models using logic and evidence (critical thinking);

Recognize and analyze explanations and models

Communicate and defend a scientific argument.

Course Content: Motion

Graph interpretations: Position vs. time

Graph interpretations: Velocity vs. time

Graph interpretations: Acceleration vs. time

Problem solving: Using graphs (average velocity, instantaneous velocity, acceleration, displacement, change in velocity)

Problem solving: Uniform acceleration including free fall (initial velocity, final velocity, time, displacement, acceleration, average velocity)

OH Grades 11-12 OH: Literacy in History/Social Studies, Science, & Technical Subjects 6-12

Writing

Text Types and Purposes 1. Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence.

WHST.11-12.1. Write arguments focused on discipline-specific content.

WHST.11-12.1a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.

WHST.11-12.1b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audiences knowledge level, concerns, values, and possible biases.

WHST.11-12.1c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.

WHST.11-12.1d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

WHST.11-12.1e. Provide a concluding statement or section that follows from or supports the argument presented.

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

WHST.11-12.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

WHST.11-12.2a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.

WHST.11-12.2b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audiences knowledge of the topic.

WHST.11-12.2c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.

WHST.11-12.2d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.

WHST.11-12.2e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).

Production and Distribution of Writing 4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

WHST.11-12.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.

WHST.11-12.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

WHST.11-12.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

Research to Build and Present Knowledge 7. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

WHST.11-12.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.

WHST.11-12.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

Draw evidence from literary or informational texts to support analysis, reflection, and research.

WHST.11-12.9. Draw evidence from informational texts to support analysis, reflection, and research.

Range of Writing 10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

WHST.11-12.10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Reading: Science & Technical Subjects

Key Ideas and Details 1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

RST.11-12.1. Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.

RST.11-12.2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Analyze how and why individuals, events, or ideas develop and interact over the course of a text.

RST.11-12.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

Craft and Structure 4. Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

RST.11-12.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 1112 texts and topics.

Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole.

RST.11-12.5. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.

Assess how point of view or purpose shapes the content and style of a text.

RST.11-12.6. Analyze the authors purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.

Integration of Knowledge and Ideas 7. Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.

RST.11-12.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.

RST.11-12.8. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

RST.11-12.9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Read and comprehend complex literary and informational texts independently and proficiently.

RST.11-12.10. By the end of grade 12, read and comprehend science/technical texts in the grades 1112 text complexity band independently and proficiently.

Capacities of the Literate Individual

Students Who are College and Career Ready in Reading, Writing, Speaking, Listening, & Language

They demonstrate independence.

Catholic Identity

DOC All Grades Catholic Identity

Catholic Social Justice Teachings

Life and Dignity of the Human Person

Rights and Responsibilities

The Dignity of Work and the Rights of Workers

Call to Family, Community, and Participation

Option for the Poor and Vulnerable

Solidarity

Care for God's Creation

The Rights of Children

1. THE RIGHT TO A CATHOLIC COMMUNITY that witnesses to Christ and the Gospel by protecting them from child abuse, including sexual abuse and neglect.

2. THE RIGHT TO A SAFE ENVIRONMENT that promotes care, protection, and security.

3. THE RIGHT TO BE RESPECTED AS INDIVIDUALS with human dignity.

4. THE RIGHT TO WORK ACTIVELY TOWARD THEIR OWN EMPOWERMENT through the development of their gifts and talents.

5. THE RIGHT TO A LEARNING ENVIRONMENT THAT VALUES COOPERATION and challenges its members to critical and reflective thinking in their search for truth.

8. THE RIGHT TO LEARN RESPONSIBILITY for themselves and their actions.

Summary

Students are introduced to methods used to model the motion of objects. They will describe the motion of objects using verbal, diagrammatical, graphical, and mathematical methods derived from experimental evidence. Learning is accomplished through the development of models from experimentation, the deployment of the models in problem solving, and the performance of lab practicums.

Unit Goals

1. Students will understand the relationship between motion and methods used to model it.
2. Students will develop models of motion and be able to deploy the models to solve problems involving moving of objects.

Big Ideas

Motion can be described and predicted using diagrams, graphs, and mathematical equations.

Enduring Understandings

1. Motion can be described by an object's position, direction and speed.
2. Motion can be measured and represented graphically.

Content

1. There is a difference in meaning between position, displacement, and distance.
2. There is a difference in meaning between speed and average velocity.
3. Velocity is the rate of change of an object's position.
4. Acceleration is the rate of change of an object's velocity.
5. The slope of an x-t graph represents the velocity of an object.
6. The slope of a v-t graph represents the acceleration of an object.
7. The area under an a-t graph represents the change in an object's velocity.
8. The area under a v-t graph represents the change in an object's position.
9. The acceleration of falling objects near the surface of Earth is nearly constant.

Skills

**Bloom's Taxonomy/DOK**

**Remember (Level 1)**

1. Use technology and mathematics to improve investigations and communications.

**Understand (Levels 1 and 2)**

1. Connect descriptions of motion to corresponding graphs.
2. Identify questions and concepts that guide scientific investigations.

**Analyze (Level 3)**

1. Determine the average velocity of an object from the slope of graphs and mathematical relationships.
2. Determine the displacement of an object from area under graphs and mathematical relationships.
3. Determine the acceleration of an object from the slope of graphs and mathematical relationships.
4. Determine the change in velocity of an object from area under graphs and mathematical relationships.
5. Recognize and analyze explanations and models.

**Evaluate (Levels 3 and 4)**

1. Apply appropriate mathematical models to new situations in order to predict future or past motion.

**Create (Level 4)**

1. Design experiments to find the relationships between quantifiable variables.
2. Create graphs from experimental data and derive mathematical relationships between variables (models).
3. Create motion maps that represent motion using dots and vectors.

Essential Questions

1. How do you measure motion?
2. How do you predict motion?
3. How are displacement and velocity related?
4. How do you graph motion?
5. How do you use area under a v-t graph to determine displacement?
6. How is the slope of an x-t graph related to velocity?
7. What is displacement?
8. What is average velocity?
9. How is the slope of a v-t graph related to an object's acceleration? What does the area under an a-t graph represent?

Stage 2: Assessment Evidence

Constant Velocity Lab

Formative: Lab Assignment

Students use battery-operated toy cars to develop graphs of constant velocity and derive the idea that average velocity is equal change in position divided by change in time.

Ultrasonic Motion Detector Lab

Formative: Lab Assignment

Students match their own motion to prepared graphs of motion using ultrasonic motion detectors.

Motion on an Incline Lab

Formative: Lab Assignment

Students study the motion of a wheel on an incline.

Toy Car Collision Lab Practicum

Summative: Performance

Given two toy cars that have different velocities, students need to predict where the cars will collide from known starting positions.

Egg Drop Lab Practicum

Summative: Performance

Students drop an egg from the top of bleachers on a teacher moving at constant velocity beneath the bleachers. Alternatively students predict where to place a current cutoff switch on the floor connected to a solenoid on the classroom ceiling holding a steel ball. The toy car must activate the switch so that steel ball hits a toy car as it moves under the switch.

Video Analysis of Motion

Summative: Performance

Students import video clips of stunts from movies to determine if the stunts are possible. For example, they determine if the bus jump in the movie Speed is really possible.

Homework

Formative: Homework

Students complete readings, writings, questions and problems.

Quizzes

Formative: Quiz

Quizzes may be used to gauge the progress of student understanding of learning content and skills.

Unit Test

Summative: Test

Students can complete Unit Test to determine understanding of concepts.

Resources

Stage 3: Learning Plan

Learning Experiences

1. Guided Inquiry
2. Cooperative Learning Groups
3. Socratic Seminar
4. Small Group and Class Discussions
5. Direct Instruction
6. Critical Thinking

Resources

Technology Integration

1. SmartBoard
2. Smart phone
3. Computers Internet
4. Graphing software (Excel, LoggerPro)
5. Vernier software and hardware
6. Pasco software and hardware
7. Video analysis software

Resources

Resources

**Books**

1. O'Kuma,T. L., Maloney, D. P., Hieggelke, C. J. (2003). *Ranking task exercises in physics.* New York: Addison-Wesley.

**YouTube**

1. MinutePhysics videos provide concise and amusing explanations for many physics topics

Resources

* Physics Classroom ([www.physicsclassroom.com](http://www.physicsclassroom.com))

Grades 9-12 Science
Physics

Newton's 1st and 3rd Laws

Stage 1: Desired Results

Catholic Standards

Targeted Standards

NGSS Grade 2 NGSS: Disciplinary Core Ideas

ETS1: Engineering Design

Defining and Delimiting an Engineering Problem

A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. (K-2-ETS1- 1) (secondary to KPS2-2)

NGSS Grade 9-12 NGSS: Crosscutting Concepts

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Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

NGSS Grade 9-12 NGSS: Science and Engineering Practices

Practice 6. Constructing explanations (for science) and designing solutions (for engineering)

Constructing explanations and designing solutions in 912 builds on K8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.

Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Practice 1. Asking questions (for science) and defining problems (for engineering)

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Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.

Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.

Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.

Ask questions to clarify and refine a model, an explanation, or an engineering problem.

Evaluate a question to determine if it is testable and relevant.

Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.

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Modeling in 912 builds on K8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Design a test of a model to ascertain its reliability.

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Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Select appropriate tools to collect, record, analyze, and evaluate data.

Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.

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Analyzing data in 912 builds on K8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

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Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.

Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.

Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.

Practice 5. Using mathematics and computational thinking

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OH Grade 9-12 OH: Science (2011)

HS Physics

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Design and conduct scientific investigations;

Use technology and mathematics to improve investigations and communications;

Formulate and revise explanations and models using logic and evidence (critical thinking);

Recognize and analyze explanations and models

Communicate and defend a scientific argument.

Course Content: Forces, momentum and motion

Newtons laws applied to complex problems

Gravitational force and fields

Friction force (static and kinetic)

Forces in two dimensions: Adding vector forces

Forces in two dimensions: Motion down inclines

OH Grades 11-12 OH: Literacy in History/Social Studies, Science, & Technical Subjects 6-12

Writing

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WHST.11-12.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

WHST.11-12.2a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.

WHST.11-12.2b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audiences knowledge of the topic.

WHST.11-12.2c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.

WHST.11-12.2d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.

WHST.11-12.2e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).

Production and Distribution of Writing 4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

WHST.11-12.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.

WHST.11-12.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

WHST.11-12.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

Research to Build and Present Knowledge 7. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

WHST.11-12.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.

WHST.11-12.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

Draw evidence from literary or informational texts to support analysis, reflection, and research.

WHST.11-12.9. Draw evidence from informational texts to support analysis, reflection, and research.

Range of Writing 10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

WHST.11-12.10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Reading: Science & Technical Subjects

Key Ideas and Details 1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

RST.11-12.1. Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.

RST.11-12.2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Analyze how and why individuals, events, or ideas develop and interact over the course of a text.

RST.11-12.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

Craft and Structure 4. Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

RST.11-12.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 1112 texts and topics.

Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole.

RST.11-12.5. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.

Assess how point of view or purpose shapes the content and style of a text.

RST.11-12.6. Analyze the authors purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.

Integration of Knowledge and Ideas 7. Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.

RST.11-12.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.

RST.11-12.8. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

RST.11-12.9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Read and comprehend complex literary and informational texts independently and proficiently.

RST.11-12.10. By the end of grade 12, read and comprehend science/technical texts in the grades 1112 text complexity band independently and proficiently.

Capacities of the Literate Individual

Students Who are College and Career Ready in Reading, Writing, Speaking, Listening, & Language

They demonstrate independence.

Catholic Identity

DOC All Grades Catholic Identity

Catholic Social Justice Teachings

Life and Dignity of the Human Person

Rights and Responsibilities

The Dignity of Work and the Rights of Workers

Call to Family, Community, and Participation

Option for the Poor and Vulnerable

Solidarity

Care for God's Creation

The Rights of Children

1. THE RIGHT TO A CATHOLIC COMMUNITY that witnesses to Christ and the Gospel by protecting them from child abuse, including sexual abuse and neglect.

2. THE RIGHT TO A SAFE ENVIRONMENT that promotes care, protection, and security.

3. THE RIGHT TO BE RESPECTED AS INDIVIDUALS with human dignity.

4. THE RIGHT TO WORK ACTIVELY TOWARD THEIR OWN EMPOWERMENT through the development of their gifts and talents.

5. THE RIGHT TO A LEARNING ENVIRONMENT THAT VALUES COOPERATION and challenges its members to critical and reflective thinking in their search for truth.

6. THE RIGHT TO DEVELOP POSITIVE, RESPONSIBLE AND CARING ATTITUDES AND BEHAVIORS TOWARD OTHERS and to recognize the rights of others to be safe and free from harassment and abuse.

8. THE RIGHT TO LEARN RESPONSIBILITY for themselves and their actions.

9. THE RIGHT TO MAKE RESPONSIBLE DECISIONS founded on religious conviction.

Summary

Students learn that forces are interactions between objects, and changes in motion are due to unbalanced forces acting upon the object. They learn to differentiate forces by how the objects that cause them interact. The link between mass and inertia is made, and the strength of the Earth's gravitational field at its surface is found to be nearly constant. Students also learn that there two types of forces, contact and field, and that forces always come in pairs. Learning is accomplished through the development of models from experimentation, the deployment of the models in problem solving, and the performance of lab practicums.

Unit Goals

1. Students will see forces as only occurring through the interaction between objects.
2. Students will recognize that changes in motion are only caused by the exertion of unbalanced forces and that objects moving at constant velocity do not require the action of a net force.
3. Students will be able identify forces acting upon objects, the agent of those forces, and reaction forces.
4. Students will be able to represent forces as vectors, decompose forces in components, quantify forces and write equations to quantify net forces.

Big Ideas

1. Forces are interactions between objects which cause changes in motion and come in pairs.

Enduring Understandings

1. The motion of an object is unchanged unless there is an unbalanced force acting upon it.
2. Inertia refers to an object's resistance to a change in its motion; it is not a force.
3. If an object exerts a force on a second object, the second object exerts the same magnitude of force back on the first object but in the opposite direction.

Content

1. Forces are interactions between two objects.
2. There are numerous forces: normal, friction, tension, traction, thrust, drag, buoyant, lift, and weight (gravitational).
3. In order for objects to accelerate, an unbalanced force must be exerted on an object.
4. Objects at rest or moving with constant velocity have no net force acting upon them.
5. If one object exerts a force on another, the other object exerts an equal force on the original object but in the opposite direction.
6. Forces are measured in Newtons and that the strength of the Earth's gravitational field at its surface is found to be nearly 10 N/kg.

Skills

**Bloom's Taxonomy/DOK**

**Remember (Level 1)**

1. Identify forces and their agents.

**Understand (Levels 1 and 2)**

1. Classify forces as being contact or field forces.
2. Represent forces as vectors and break them into components using trigonometry.
3. Formulate mathematical equations from free body diagrams to quantify forces.

**Analyze (Level 3)**

1. Assess whether forces acting upon an object are balanced or not by analyzing motion.
2. Analyze situations where forces are present and draw free body diagrams (force diagrams) representing the situation.
3. Analyze forces using the simplest coordinate axes.
4. Recognize and analyze explanations and models.

**Evaluate (Levels 3 and 4)**

1. Formulate and revise explanations and models using logic and evidence (critical thinking).

**Create (Level 4)**

1. Design experiments to find the relationships between quantifiable variables.
2. Create graphs from experimental data and derive mathematical relationships between variables (models).

Essential Questions

1. What is a force?
2. What is a balanced force?
3. What is an unbalanced force?
4. How do you measure a force?
5. What is a vector?
6. What is a scalar?
7. What is a vector component?
8. How do you represent or model a force?
9. What is the difference between mass and weight?
10. What is a change in motion?
11. How do you add forces together?
12. What force does the Earth's gravitational field exert on a mass?
13. How are field forces different from contact forces?

Stage 2: Assessment Evidence

Bowling Ball Lab

Formative: Lab Assignment

This lab is a great way to introduce students to Newton's 1st Law. Students are to use brooms to navigate a bowling ball through an obstacle course as quickly as possible. After the race, the students are required to analyze the motion of the bowling ball and its interaction with the broom and discuss their findings as a class. The attached link fully describes the activity and has student handouts.

Weight & Mass Lab

Formative: Lab Assignment

Students use spring scales or electronic force sensors to find the relationship between the mass of objects and their weights (force of gravity). Students will find that the graph of force vs. mass is a straight line (direct relationship) with a slope of about 10 N/kg, the gravitational field strength near the Earth's surface.

Newton's 3rd Law Demonstration

Formative: Class Discussion

The teacher can use a pair of bathroom scales, spring scales, and/or force sensors to demonstrate Newton's 3rd Law. See attached links. Teacher can use skateboards or human dynamics carts to do similar demonstrations.

Homework

Formative: Homework

Students can complete readings, questions and problems.

Quizzes

Formative: Quiz

Quizzes can be used to gauge the progress of student understanding of learning content and skills.

Unit Test

Summative: Test

Students can be given a Unit Test to determine understanding of concepts.

Stage 3: Learning Plan

Learning Experiences

1. Guided Inquiry
2. Cooperative Learning Groups
3. Socratic Seminar
4. Small Group and Class Discussions
5. Direct Instruction
6. Critical Thinking

Technology Integration

1. SmartBoard
2. Smart phone
3. Computers Internet
4. Graphing software (Excel, LoggerPro)
5. Vernier software and hardware
6. Pasco software and hardware
7. Video analysis software

Resources

Resources

**Books**

1. O'Kuma,T. L., Maloney, D. P., Hieggelke, C. J. (2003). *Ranking task exercises in physics.* New York: Addison-Wesley.

**YouTube**

1. MinutePhysics videos provide concise and amusing explanations for many physics topics.

Resources

* Physics Classroom (<http://www.physicsclassroom.com>)

Grades 9-12 Science
Physics

Newton's 2nd Law

Stage 1: Desired Results

Catholic Standards

DOC All Grades DOC: Catholic Standards

The Profession of Faith

Students will be able to

1. Recognize God in the world's order, beauty, and goodness (CCC 32).

Life in Christ

Students will be able to

2. Know that we must assume responsibility for the acts we perform (CCC 1781).

12. Respect the integrity of all creation, including animals, plants, and all nature (CCC 2415).

Targeted Standards

NGSS Grade 2 NGSS: Disciplinary Core Ideas

ETS1: Engineering Design

Defining and Delimiting an Engineering Problem

A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. (K-2-ETS1- 1) (secondary to KPS2-2)

NGSS Grade 9-12 NGSS: Crosscutting Concepts

Crosscutting Statements

Patterns Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

NGSS Grade 9-12 NGSS: Science and Engineering Practices

Practice 8. Obtaining, evaluating, and communicating information

Obtaining, evaluating, and communicating information in 912 builds on K8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.

Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Practice 6. Constructing explanations (for science) and designing solutions (for engineering)

Constructing explanations and designing solutions in 912 builds on K8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.

Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Practice 7. Engaging in argument from evidence

Engaging in argument from evidence in 912 builds on K8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.

Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Practice 1. Asking questions (for science) and defining problems (for engineering)

Asking questions and defining problems in 912 builds on K8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.

Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.

Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.

Ask questions to clarify and refine a model, an explanation, or an engineering problem.

Evaluate a question to determine if it is testable and relevant.

Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.

Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.

Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and/or environmental considerations.

Practice 2. Developing and using models

Modeling in 912 builds on K8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria.

Design a test of a model to ascertain its reliability.

Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.

Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Practice 3. Planning and carrying out investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigations design to ensure variables are controlled.

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.

Select appropriate tools to collect, record, analyze, and evaluate data.

Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.

Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

Practice 4. Analyzing and interpreting data

Analyzing data in 912 builds on K8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.

Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.

Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.

Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.

Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Practice 5. Using mathematics and computational thinking

Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Apply techniques of algebra and functions to represent and solve scientific and engineering problems.

Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model makes sense by comparing the outcomes with what is known about the real world.

Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).

OH Grade 9-12 OH: Science (2011)

HS Physics

Science Inquiry and Application During the years of grades 9 through 12 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

Identify questions and concepts that guide scientific investigations;

Design and conduct scientific investigations;

Use technology and mathematics to improve investigations and communications;

Formulate and revise explanations and models using logic and evidence (critical thinking);

Recognize and analyze explanations and models

Communicate and defend a scientific argument.

Course Content: Motion

Graph interpretations: Position vs. time

Graph interpretations: Velocity vs. time

Graph interpretations: Acceleration vs. time

Problem solving: Using graphs (average velocity, instantaneous velocity, acceleration, displacement, change in velocity)

Problem solving: Uniform acceleration including free fall (initial velocity, final velocity, time, displacement, acceleration, average velocity)

Course Content: Forces, momentum and motion

Newtons laws applied to complex problems

Gravitational force and fields

Friction force (static and kinetic)

Forces in two dimensions: Adding vector forces

Forces in two dimensions: Motion down inclines

OH Grades 11-12 OH: Literacy in History/Social Studies, Science, & Technical Subjects 6-12

Writing

Text Types and Purposes 1. Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence.

WHST.11-12.1. Write arguments focused on discipline-specific content.

WHST.11-12.1a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.

WHST.11-12.1b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audiences knowledge level, concerns, values, and possible biases.

WHST.11-12.1c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.

WHST.11-12.1d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

WHST.11-12.1e. Provide a concluding statement or section that follows from or supports the argument presented.

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

WHST.11-12.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

WHST.11-12.2a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.

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Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.

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Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

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RST.11-12.2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Analyze how and why individuals, events, or ideas develop and interact over the course of a text.

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RST.11-12.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 1112 texts and topics.

Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole.

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Rights and Responsibilities

The Dignity of Work and the Rights of Workers

Call to Family, Community, and Participation

Option for the Poor and Vulnerable

Solidarity

Care for God's Creation

The Rights of Children

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2. THE RIGHT TO A SAFE ENVIRONMENT that promotes care, protection, and security.

3. THE RIGHT TO BE RESPECTED AS INDIVIDUALS with human dignity.

4. THE RIGHT TO WORK ACTIVELY TOWARD THEIR OWN EMPOWERMENT through the development of their gifts and talents.

5. THE RIGHT TO A LEARNING ENVIRONMENT THAT VALUES COOPERATION and challenges its members to critical and reflective thinking in their search for truth.

6. THE RIGHT TO DEVELOP POSITIVE, RESPONSIBLE AND CARING ATTITUDES AND BEHAVIORS TOWARD OTHERS and to recognize the rights of others to be safe and free from harassment and abuse.

8. THE RIGHT TO LEARN RESPONSIBILITY for themselves and their actions.

Summary

Newton's 2nd law of motion is introduced. Students learn through experimentation that an object's acceleration is directly related to the net force acting upon it and inversely proportional to its mass or inertia. They are expected to apply kinematic models developed in the previous unit into problems involving accelerated motion. Static and kinetic friction are studied through experimentation, and students find that the frictional forces are directly proportional to normal forces acting upon the objects and that the proportional constant is known as a coefficient of friction.

Unit Goals

1. Students will understand that unbalanced forces acting on objects result in accelerations.
2. Students will be able to solve quantitative problems involving forces, mass, and acceleration using Newton's 2nd Law through the use of free body diagrams and descriptions of motion.
3. Students will be able to quantitatively determine frictional forces using free body diagrams, descriptions of motion, and knowledge of coefficients of friction.

Big Ideas

Changes in speed, direction, or both are always caused by unbalanced forces.

Enduring Understandings

1. The acceleration of any object is due to a net force on the object.
2. The acceleration of an object is directly proportional to the net force acting on the object and inversely proportional to its mass.
3. A frictional force between the surfaces of two objects generally depends on some fraction of normal force.

Content

1. The total unbalanced force acting on an object is called the net force.
2. Acceleration is directly proportional to the net force acting on an object or system.
3. Acceleration is inversely proportional to the mass of the object or system.
4. Friction forces are largely dependent on some fraction of the normal force.

Skills

**Bloom's Taxonomy/DOK**

**Remember (Level 1)**

1. Identify questions and concepts that guide scientific investigations.
2. Use technology and mathematics to improve investigations and communications.

**Understand (Levels 1 and 2)**

1. Represent forces as vectors and break them into components using trigonometry.

**Analyze (Level 3)**

1. Analyze situations where forces are present and draw free body diagrams (force diagrams) representing the situation in order to determine net forces acting on objects.
2. Analyze forces and/or descriptions of motion to make predictions involving acceleration.

Recognize and analyze explanations and models.

**Evaluate (Levels 3 and 4)**

1. Formulate and revise explanations and models using logic and evidence (critical thinking).

Communicate and defend a scientific argument.

**Create (Level 4)**

1. Design experiments to find the relationships between quantifiable variables.
2. Create graphs from experimental data and derive mathematical relationships between variables (models).
3. Design and conduct scientific investigations.

Essential Questions

1. How do you determine the net force acting on an object?
2. How are forces and motion related?
3. How does the acceleration of an object depend on its mass and the net force acting on it?
4. What factors affect the magnitude of friction between the surfaces of two objects?

Stage 2: Assessment Evidence

Modified Atwood's Machine Lab

Formative: Lab Assignment

Students employ a modified Atwood's machine and electronic motion sensors or photogates to determine the relationship between acceleration and mass and acceleration and net force. Graphs of a vs m and a vs Fnet are analyzed to find relationships. Newton's 2nd law of motion is developed during group discussion.

Elevator Forces Lab

Formative: Lab Assignment

Students stand on scales while riding in an elevator. This activity helps to reinforce the difference in the ideas of weight and normal forces through kinesthetic learning experiences (see link below for example handout). If you do not have access to an elevator, videos showing the changes in scale readings can be substituted (see link below).

Friction Lab

Formative: Lab Assignment

Students use spring scales or electronic force sensors to drag objects (blocks of wood) across various surfaces to find what variables have an effect on frictional force. Students will find that frictional force is directly dependent on normal force. Slope of graphs of friction vs. normal forces is coefficient of friction.

Homework

Formative: Homework

Students can use readings, questions and problems to demonstrate understanding.

Quizzes

Formative: Quiz

Quizzes are used to gauge the progress of student understanding of learning content and skills.

Unit Test

Summative: Test

Students may take a Unit Test to demonstrate understanding.

Resources

Stage 3: Learning Plan

Learning Experiences

1. Guided Inquiry
2. Cooperative Learning Groups
3. Socratic Seminar
4. Small Group and Class Discussions
5. Direct Instruction
6. Critical Thinking

Resources

Technology Integration

1. SmartBoard
2. Smart phone
3. Computers Internet
4. Graphing software (Excel, LoggerPro)
5. Vernier software and hardware
6. Pasco software and hardware
7. Video analysis software

Resources

Resources

**Books**

1. O'Kuma,T. L., Maloney, D. P., Hieggelke, C. J. (2003). *Ranking task exercises in physics.* New York: Addison-Wesley.

**YouTube**

1. MinutePhysics videos provide concise and amusing explanations for many physics topics

Resources

* Hippo Campus (<http://www.hippocampus.org/HippoCampus/Physics>)

Grades 9-12 Science
Physics

Two Dimensional Kinematics

Stage 1: Desired Results

Catholic Standards

DOC All Grades DOC: Catholic Standards

The Profession of Faith

Students will be able to

1. Recognize God in the world's order, beauty, and goodness (CCC 32).

Life in Christ

Students will be able to

2. Know that we must assume responsibility for the acts we perform (CCC 1781).

12. Respect the integrity of all creation, including animals, plants, and all nature (CCC 2415).

Targeted Standards

NGSS Grade 2 NGSS: Disciplinary Core Ideas

ETS1: Engineering Design

Defining and Delimiting an Engineering Problem

A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. (K-2-ETS1- 1) (secondary to KPS2-2)

NGSS Grade 9-12 NGSS: Crosscutting Concepts

Crosscutting Statements

Patterns Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

NGSS Grade 9-12 NGSS: Science and Engineering Practices

Practice 8. Obtaining, evaluating, and communicating information

Obtaining, evaluating, and communicating information in 912 builds on K8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.

Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Practice 6. Constructing explanations (for science) and designing solutions (for engineering)

Constructing explanations and designing solutions in 912 builds on K8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.

Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

Practice 7. Engaging in argument from evidence

Engaging in argument from evidence in 912 builds on K8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.

Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.

Practice 1. Asking questions (for science) and defining problems (for engineering)

Asking questions and defining problems in 912 builds on K8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.

Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.

Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.

Ask questions to clarify and refine a model, an explanation, or an engineering problem.

Evaluate a question to determine if it is testable and relevant.

Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.

Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.

Practice 2. Developing and using models

Modeling in 912 builds on K8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria.

Design a test of a model to ascertain its reliability.

Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.

Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Practice 3. Planning and carrying out investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigations design to ensure variables are controlled.

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.

Select appropriate tools to collect, record, analyze, and evaluate data.

Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.

Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

Practice 4. Analyzing and interpreting data

Analyzing data in 912 builds on K8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.

Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.

Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.

Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.

Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Practice 5. Using mathematics and computational thinking

Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Apply techniques of algebra and functions to represent and solve scientific and engineering problems.

Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model makes sense by comparing the outcomes with what is known about the real world.

Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).

OH Grade 9-12 OH: Science (2011)

HS Physics

Science Inquiry and Application During the years of grades 9 through 12 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

Identify questions and concepts that guide scientific investigations;

Design and conduct scientific investigations;

Use technology and mathematics to improve investigations and communications;

Formulate and revise explanations and models using logic and evidence (critical thinking);

Recognize and analyze explanations and models

Communicate and defend a scientific argument.

Course Content: Motion

Projectiles: Independence of horizontal and vertical motion

Projectiles: Problem-solving involving horizontally launched projectiles

Course Content: Forces, momentum and motion

Gravitational force and fields

Forces in two dimensions: Adding vector forces

OH Grades 11-12 OH: Literacy in History/Social Studies, Science, & Technical Subjects 6-12

Writing

Text Types and Purposes 1. Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence.

WHST.11-12.1. Write arguments focused on discipline-specific content.

WHST.11-12.1a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.

WHST.11-12.1b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audiences knowledge level, concerns, values, and possible biases.

WHST.11-12.1c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.

WHST.11-12.1d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

WHST.11-12.1e. Provide a concluding statement or section that follows from or supports the argument presented.

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

WHST.11-12.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

WHST.11-12.2a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.

WHST.11-12.2b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audiences knowledge of the topic.

WHST.11-12.2c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.

WHST.11-12.2d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.

WHST.11-12.2e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).

Production and Distribution of Writing 4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

WHST.11-12.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.

WHST.11-12.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

WHST.11-12.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

Research to Build and Present Knowledge 7. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

WHST.11-12.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.

WHST.11-12.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

Draw evidence from literary or informational texts to support analysis, reflection, and research.

WHST.11-12.9. Draw evidence from informational texts to support analysis, reflection, and research.

Range of Writing 10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

WHST.11-12.10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Reading: Science & Technical Subjects

Key Ideas and Details 1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

RST.11-12.1. Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.

RST.11-12.2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Analyze how and why individuals, events, or ideas develop and interact over the course of a text.

RST.11-12.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

Craft and Structure 4. Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

RST.11-12.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 1112 texts and topics.

Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole.

RST.11-12.5. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.

Assess how point of view or purpose shapes the content and style of a text.

RST.11-12.6. Analyze the authors purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.

Integration of Knowledge and Ideas 7. Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.

RST.11-12.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.

RST.11-12.8. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

RST.11-12.9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Read and comprehend complex literary and informational texts independently and proficiently.

RST.11-12.10. By the end of grade 12, read and comprehend science/technical texts in the grades 1112 text complexity band independently and proficiently.

Capacities of the Literate Individual

Students Who are College and Career Ready in Reading, Writing, Speaking, Listening, & Language

They demonstrate independence.

Catholic Identity

DOC All Grades Catholic Identity

Catholic Social Justice Teachings

Life and Dignity of the Human Person

Rights and Responsibilities

The Dignity of Work and the Rights of Workers

Call to Family, Community, and Participation

Option for the Poor and Vulnerable

Solidarity

Care for God's Creation

The Rights of Children

1. THE RIGHT TO A CATHOLIC COMMUNITY that witnesses to Christ and the Gospel by protecting them from child abuse, including sexual abuse and neglect.

2. THE RIGHT TO A SAFE ENVIRONMENT that promotes care, protection, and security.

3. THE RIGHT TO BE RESPECTED AS INDIVIDUALS with human dignity.

4. THE RIGHT TO WORK ACTIVELY TOWARD THEIR OWN EMPOWERMENT through the development of their gifts and talents.

5. THE RIGHT TO A LEARNING ENVIRONMENT THAT VALUES COOPERATION and challenges its members to critical and reflective thinking in their search for truth.

6. THE RIGHT TO DEVELOP POSITIVE, RESPONSIBLE AND CARING ATTITUDES AND BEHAVIORS TOWARD OTHERS and to recognize the rights of others to be safe and free from harassment and abuse.

8. THE RIGHT TO LEARN RESPONSIBILITY for themselves and their actions.

9. THE RIGHT TO MAKE RESPONSIBLE DECISIONS founded on religious conviction.

Summary

The students learn that projectiles move in parabolic paths and that the horizontal and vertical motion are completely independent of each other.

Unit Goals

1. Students learn that the motion of projectile can be treated as a combination of two models of motion developed in a prior unit.
2. Students are also expected to be able to decompose velocity vectors in the same way they decomposed force vectors in prior units having to do with Newton's Laws.

Big Ideas

1. Two-dimensional motion can be described by combining one-dimensional models.

Enduring Understandings

1. All motion can be separated into horizontal and vertical components.
2. Motion in the horizontal direction is independent of motion in the vertical direction.
3. All motion is relative.

Content

1. Motion is relative.
2. Projectiles trace parabolic paths.
3. The only force acting on projectiles is gravity (in the absence of air resistance).
4. Projectiles accelerate uniformly only in the vertical direction due to gravity.
5. Projectiles move with constant velocity in the horizontal direction.
6. Time is the only variable that is common to both the horizontal and vertical components of projectile motion.

Skills

**Bloom's Taxonomy/DOK**

**Remember (Level 1)**

1. Identify questions and concepts that guide scientific investigations.
2. Use technology and mathematics to improve investigations and communications.

**Understand (Levels 1 and 2)**

**Analyze (Level 3)**

1. Analyze motion of projectiles to mathematically solve problems involving projectile motion.
2. Decompose velocity of projectiles into horizontal and vertical components using trigonometry.
3. Use technology and mathematics to improve investigations and communications.

Recognize and analyze explanations and models.

**Evaluate (Levels 3 and 4)**

1. Communicate and defend a scientific argument.

**Create (Level 4)**

1. Design experiments to find the relationships between quantifiable variables.
2. Create graphs from experimental data and derive mathematical relationships between variables (models).

Design and conduct scientific investigations.

Essential Questions

1. How does the range of a projectile depend on its launch angle?
2. Why will an object that is launched horizontally and an identical object that is dropped from the same launch height both hit the ground at the same time?

Stage 2: Assessment Evidence

Projectile Motion Video Analysis Lab

Formative: Lab Assignment

Students take videos of projectile motion (ball tossed through air) using smart phones and employ video analysis software to make separate graphs of vertical position versus time and horizontal position versus time. Students analyze motion depicted by graphs to see that projectile moves with constant velocity in the horizontal direction and uniformly accelerated motion in the vertical direction. Vernier and Pasco both offer video capture and analysis software; a link to free software is below.

Model of Projectile Motion

Formative: Project

Students create physical models of projectiles. Using meter sticks, strings, and small weights, students mark predicted positions of projectiles launched at various angles for short periods of flight. See link below for example.

Projectile Motion Lab Practicum

Summative: Performance

Students are shown a ramp on a table with a marble at the top of the ramp. Students are asked to predict where the marble will land on the floor when it leaves the ramp and table. They must place a small cup where they think the marble will land. Students are expected to solve the problem using meter sticks, timers, photogates, motion sensors, plumb bobs and little to no teacher directions.

Homework

Formative: Homework

Students can use readings, questions and problems to practice concepts.

Quizzes

Formative: Quiz

Quizzes are used to gauge the progress of student understanding of learning content and skills.

Unit Test

Summative: Test

Students may take a Unit Test to demonstrate understanding.

Stage 3: Learning Plan

Learning Experiences

1. Guided Inquiry
2. Cooperative Learning Groups
3. Socratic Seminar
4. Small Group and Class Discussions
5. Direct Instruction
6. Critical Thinking

Technology Integration

1. SmartBoard
2. Smart phone
3. Computers Internet
4. Graphing software (Excel, LoggerPro)
5. Vernier software and hardware
6. Pasco software and hardware
7. Video analysis software

Resources

**Books**

1. O'Kuma,T. L., Maloney, D. P., Hieggelke, C. J. (2003). *Ranking task exercises in physics.* New York: Addison-Wesley.

**YouTube**

1. MinutePhysics videos provide concise and amusing explanations for many physics topics.

Resources

* Physics Classroom (<http://www.physicsclassroom.com/>)

Grades 9-12 Science
Physics

Uniform Circular Motion

Stage 1: Desired Results

Catholic Standards

DOC All Grades DOC: Catholic Standards

The Profession of Faith

Students will be able to

1. Recognize God in the world's order, beauty, and goodness (CCC 32).

Life in Christ

Students will be able to

2. Know that we must assume responsibility for the acts we perform (CCC 1781).

12. Respect the integrity of all creation, including animals, plants, and all nature (CCC 2415).

Targeted Standards

NGSS Grade 2 NGSS: Disciplinary Core Ideas

ETS1: Engineering Design

Defining and Delimiting an Engineering Problem

A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. (K-2-ETS1- 1) (secondary to KPS2-2)

NGSS Grade 9-12 NGSS: Crosscutting Concepts

Crosscutting Statements

Patterns Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

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Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.

Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Practice 6. Constructing explanations (for science) and designing solutions (for engineering)

Constructing explanations and designing solutions in 912 builds on K8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.

Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Practice 7. Engaging in argument from evidence

Engaging in argument from evidence in 912 builds on K8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.

Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Practice 1. Asking questions (for science) and defining problems (for engineering)

Asking questions and defining problems in 912 builds on K8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.

Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.

Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.

Ask questions to clarify and refine a model, an explanation, or an engineering problem.

Evaluate a question to determine if it is testable and relevant.

Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.

Practice 2. Developing and using models

Modeling in 912 builds on K8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria.

Design a test of a model to ascertain its reliability.

Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.

Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Practice 3. Planning and carrying out investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigations design to ensure variables are controlled.

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.

Select appropriate tools to collect, record, analyze, and evaluate data.

Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.

Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

Practice 4. Analyzing and interpreting data

Analyzing data in 912 builds on K8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.

Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.

Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.

Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.

Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Practice 5. Using mathematics and computational thinking

Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Apply techniques of algebra and functions to represent and solve scientific and engineering problems.

Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model makes sense by comparing the outcomes with what is known about the real world.

Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).

OH Grade 9-12 OH: Science (2011)

HS Physics

Science Inquiry and Application During the years of grades 9 through 12 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

Identify questions and concepts that guide scientific investigations;

Design and conduct scientific investigations;

Use technology and mathematics to improve investigations and communications;

Formulate and revise explanations and models using logic and evidence (critical thinking);

Recognize and analyze explanations and models

Communicate and defend a scientific argument.

Course Content: Forces, momentum and motion

Gravitational force and fields

Forces in two dimensions: Centripetal forces and circular motion

OH Grades 11-12 OH: Literacy in History/Social Studies, Science, & Technical Subjects 6-12

Writing

Text Types and Purposes 1. Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence.

WHST.11-12.1. Write arguments focused on discipline-specific content.

WHST.11-12.1a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.

WHST.11-12.1b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audiences knowledge level, concerns, values, and possible biases.

WHST.11-12.1c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.

WHST.11-12.1d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

WHST.11-12.1e. Provide a concluding statement or section that follows from or supports the argument presented.

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

WHST.11-12.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

WHST.11-12.2a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.

WHST.11-12.2b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audiences knowledge of the topic.

WHST.11-12.2c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.

WHST.11-12.2d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.

WHST.11-12.2e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).

Production and Distribution of Writing 4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

WHST.11-12.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.

WHST.11-12.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

WHST.11-12.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

Research to Build and Present Knowledge 7. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

WHST.11-12.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.

WHST.11-12.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

Draw evidence from literary or informational texts to support analysis, reflection, and research.

WHST.11-12.9. Draw evidence from informational texts to support analysis, reflection, and research.

Range of Writing 10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

WHST.11-12.10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Reading: Science & Technical Subjects

Key Ideas and Details 1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

RST.11-12.1. Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.

RST.11-12.2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Analyze how and why individuals, events, or ideas develop and interact over the course of a text.

RST.11-12.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

Craft and Structure 4. Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

RST.11-12.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 1112 texts and topics.

Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole.

RST.11-12.5. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.

Assess how point of view or purpose shapes the content and style of a text.

RST.11-12.6. Analyze the authors purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.

Integration of Knowledge and Ideas 7. Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.

RST.11-12.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.

RST.11-12.8. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

RST.11-12.9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Read and comprehend complex literary and informational texts independently and proficiently.

RST.11-12.10. By the end of grade 12, read and comprehend science/technical texts in the grades 1112 text complexity band independently and proficiently.

Capacities of the Literate Individual

Students Who are College and Career Ready in Reading, Writing, Speaking, Listening, & Language

They demonstrate independence.

Catholic Identity

DOC All Grades Catholic Identity

Catholic Social Justice Teachings

Life and Dignity of the Human Person

Rights and Responsibilities

The Dignity of Work and the Rights of Workers

Call to Family, Community, and Participation

Option for the Poor and Vulnerable

Solidarity

Care for God's Creation

The Rights of Children

1. THE RIGHT TO A CATHOLIC COMMUNITY that witnesses to Christ and the Gospel by protecting them from child abuse, including sexual abuse and neglect.

2. THE RIGHT TO A SAFE ENVIRONMENT that promotes care, protection, and security.

3. THE RIGHT TO BE RESPECTED AS INDIVIDUALS with human dignity.

4. THE RIGHT TO WORK ACTIVELY TOWARD THEIR OWN EMPOWERMENT through the development of their gifts and talents.

5. THE RIGHT TO A LEARNING ENVIRONMENT THAT VALUES COOPERATION and challenges its members to critical and reflective thinking in their search for truth.

6. THE RIGHT TO DEVELOP POSITIVE, RESPONSIBLE AND CARING ATTITUDES AND BEHAVIORS TOWARD OTHERS and to recognize the rights of others to be safe and free from harassment and abuse.

8. THE RIGHT TO LEARN RESPONSIBILITY for themselves and their actions.

9. THE RIGHT TO MAKE RESPONSIBLE DECISIONS founded on religious conviction.

Summary

Students are introduced to the idea that an unbalanced force is necessary in order for an object to move along a circular path.

Unit Goals

1. Students will identify centripetal forces and apply Newton's 2nd Law of motion to find solutions to problems involving orbiting objects.

Big Ideas

1. A net force is required to move an object in a curved path.

Enduring Understandings

1. A change in velocity due to a curved motion is an acceleration.
2. Acceleration is caused by a net force exerted on a moving object.
3. The force of gravity between two objects is directly proportional to the product of their masses and inversely proportional to the square of the distance between the objects.
4. Circular motion requires a net inward force.

Content

1. Objects moving with a constant speed while moving in a circular path are accelerating.
2. A centripetal acceleration acts toward the center of a circle.
3. Any force or combination of forces which can cause a centripetal acceleration are called centripetal forces.
4. Centripetal acceleration is directly proportional to the square of the tangential velocity and inversely proportional to the radius of the orbit.

Skills

**Blooms Taxonomy/DOK**

**Remember (Level 1)**

1. Identify questions and concepts that guide scientific investigations.
2. Use technology and mathematics to improve investigations and communications.
3. Use mathematical representations of Newtons Law of Gravitation and Coulombs Law to describe and predict the gravitational and electrostatic forces between objects.

**Understand (Levels 1 and 2)**

1. Represent forces as vectors and break them into components using trigonometry.
2. Apply Newton's 2nd Law of Motion and Law of Universal Gravitation to situations involving orbits of satellites to determine orbital altitudes and velocities.
3. Apply Newton's 2nd Law of Motion to find the necessary net force to keep an object moving in a circular path.

**Analyze (Level 3)**

1. Analyze situations where forces are present and draw free body diagrams (force diagrams) representing the situation in order to determine net forces acting on objects.
2. Formulate and revise explanations and models using logic and evidence (critical thinking).
3. Recognize and analyze explanations and models.
4. Analyze data to support the claim that Newtons 2nd Law of Motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

**Evaluate (Levels 3 and 4)**

1. Communicate and defend a scientific argument.

Evaluate a question to determine if it is testable and relevant.

**Create (Level 4)**

1. Design experiments to find the relationships between quantifiable variables.
2. Create graphs from experimental data and derive mathematical relationships between variables (models).

Design and conduct scientific investigations.

Essential Questions

1. What is uniform circular motion?
2. How is centripetal acceleration determined?
3. How is centripetal force different from centrifugal force?
4. What kinds of forces are responsible for circular motion?
5. In what direction is centripetal force pointed?
6. What factors affect the gravitational attraction between two objects?

Stage 2: Assessment Evidence

Uniform Circular Motion Lab

Formative: Lab Assignment

Students whirl rubber stoppers attached to force sensors or known weights to determine the relationships between tangential velocity and force, mass and force, and radius and force. After graphing results, students are expected to find the mathematical relationships between these variables and construct a model for centripetal acceleration. Use link below for good video of lab performance.

Flying Pig Lab Practicum

Summative: Performance

Students observe a circular motion toy (flying pig, see link below) and must determine the tension in the string when given the length of the string and the angle the string makes with the vertical or horizontal.

Homework

Formative: Homework

Students may use readings, writings, questions and problems to understand concepts.

Quizzes

Formative: Quiz

Quizzes are used to gauge the progress of student understanding of learning content and skills.

Unit Test

Summative: Test

Students may take a Unit Test to demonstrate understanding.

Resources

Stage 3: Learning Plan

Learning Experiences

1. Guided Inquiry
2. Cooperative Learning Groups
3. Socratic Seminar
4. Small Group and Class Discussions
5. Direct Instruction
6. Critical Thinking

Technology Integration

1. SmartBoard
2. Smart phone
3. Computers Internet
4. Graphing software (Excel, LoggerPro)
5. Vernier software and hardware
6. Pasco software and hardware
7. Video analysis software

Resources

Resources

**Books**

1. O'Kuma,T. L., Maloney, D. P., Hieggelke, C. J. (2003). *Ranking task exercises in physics.* New York: Addison-Wesley.

**YouTube**

1. MinutePhysics videos provide concise and amusing explanations for many physics topics.

Resources

* Physics Classroom (<http://www.physicsclassroom.com/>)

Grades 9-12 Science
Physics

Energy

Stage 1: Desired Results

Catholic Standards

DOC All Grades DOC: Catholic Standards

The Profession of Faith

Students will be able to

1. Recognize God in the world's order, beauty, and goodness (CCC 32).

8. Understand that the world was made for the glory of God, the Creator of all things (CCC 290; 293).

Life in Christ

Students will be able to

2. Know that we must assume responsibility for the acts we perform (CCC 1781).

12. Respect the integrity of all creation, including animals, plants, and all nature (CCC 2415).

Targeted Standards

NGSS Grade 2 NGSS: Disciplinary Core Ideas

ETS1: Engineering Design

Defining and Delimiting an Engineering Problem

A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. (K-2-ETS1- 1) (secondary to KPS2-2)

NGSS Grade 9-12 NGSS: Crosscutting Concepts

Crosscutting Statements

Patterns Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

NGSS Grade 9-12 NGSS: Science and Engineering Practices

Practice 8. Obtaining, evaluating, and communicating information

Obtaining, evaluating, and communicating information in 912 builds on K8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.

Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Practice 6. Constructing explanations (for science) and designing solutions (for engineering)

Constructing explanations and designing solutions in 912 builds on K8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.

Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Practice 7. Engaging in argument from evidence

Engaging in argument from evidence in 912 builds on K8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.

Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

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Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.

Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.

Ask questions to clarify and refine a model, an explanation, or an engineering problem.

Evaluate a question to determine if it is testable and relevant.

Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.

Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.

Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and/or environmental considerations.

Practice 2. Developing and using models

Modeling in 912 builds on K8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria.

Design a test of a model to ascertain its reliability.

Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.

Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

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Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigations design to ensure variables are controlled.

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.

Select appropriate tools to collect, record, analyze, and evaluate data.

Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.

Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

Practice 4. Analyzing and interpreting data

Analyzing data in 912 builds on K8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.

Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.

Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.

Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.

Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

OH Grade 9-12 OH: Science (2011)

HS Physics

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Identify questions and concepts that guide scientific investigations;

Design and conduct scientific investigations;

Use technology and mathematics to improve investigations and communications;

Formulate and revise explanations and models using logic and evidence (critical thinking);

Recognize and analyze explanations and models

Communicate and defend a scientific argument.

Course Content: Energy

Gravitational potential energy

Energy in springs

Nuclear energy

Work and power

Conservation of energy

OH Grades 11-12 OH: Literacy in History/Social Studies, Science, & Technical Subjects 6-12

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Text Types and Purposes 1. Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence.

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WHST.11-12.1b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audiences knowledge level, concerns, values, and possible biases.

WHST.11-12.1c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.

WHST.11-12.1d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

WHST.11-12.1e. Provide a concluding statement or section that follows from or supports the argument presented.

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

WHST.11-12.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

WHST.11-12.2a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.

WHST.11-12.2b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audiences knowledge of the topic.

WHST.11-12.2c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.

WHST.11-12.2d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.

WHST.11-12.2e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).

Production and Distribution of Writing 4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

WHST.11-12.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.

WHST.11-12.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

WHST.11-12.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

Research to Build and Present Knowledge 7. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

WHST.11-12.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.

WHST.11-12.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

Draw evidence from literary or informational texts to support analysis, reflection, and research.

WHST.11-12.9. Draw evidence from informational texts to support analysis, reflection, and research.

Range of Writing 10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

WHST.11-12.10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Reading: Science & Technical Subjects

Key Ideas and Details 1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

RST.11-12.1. Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.

RST.11-12.2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Analyze how and why individuals, events, or ideas develop and interact over the course of a text.

RST.11-12.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

Craft and Structure 4. Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

RST.11-12.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 1112 texts and topics.

Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole.

RST.11-12.5. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.

Assess how point of view or purpose shapes the content and style of a text.

RST.11-12.6. Analyze the authors purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.

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Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

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Students Who are College and Career Ready in Reading, Writing, Speaking, Listening, & Language

They demonstrate independence.

Catholic Identity

DOC All Grades Catholic Identity

Catholic Social Justice Teachings

Life and Dignity of the Human Person

Rights and Responsibilities

The Dignity of Work and the Rights of Workers

Call to Family, Community, and Participation

Option for the Poor and Vulnerable

Solidarity

Care for God's Creation

The Rights of Children

1. THE RIGHT TO A CATHOLIC COMMUNITY that witnesses to Christ and the Gospel by protecting them from child abuse, including sexual abuse and neglect.

2. THE RIGHT TO A SAFE ENVIRONMENT that promotes care, protection, and security.

3. THE RIGHT TO BE RESPECTED AS INDIVIDUALS with human dignity.

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Summary

Students are introduced to the idea that energy is a substance-like quantity which is conserved and has the capability to produce change. The ideas of work being a transfer of energy and power as the rate of energy transfer will also be covered.

Unit Goals

1. Students will understand that energy is required to produce change.
2. Students will know that energy is a conserved, substance-like quantity that can be transferred into or out of systems.
3. Students will know that energy is either stored within an object or within a field and that work is the transfer of energy into or out of systems through the applications of external forces.
4. Students will know that energy can be transferred in three ways: work, heat, and radiation.
5. Students will know that the rate at which energy is transferred is called power.

Big Ideas

1. Energy is a conserved substance-like quality with the capability to produce change in a physical system.

Enduring Understandings

1. Energy is a conserved quantity.
2. Energy is necessary to produce change.
3. Energy can be transferred between systems and their surroundings.
4. Energy can be stored.

Content

1. Energy is required to produce change in physical systems.
2. The total initial energy of a system plus any energy transferred into or out of it must equal the total final energy.
3. Energy is stored within objects (kinetic or elastic) or within fields (gravitational, electric or magnetic).
4. Work is the transfer of energy between a system and it surroundings by an external force.
5. If there is a change in kinetic energy of a system, then that change in energy is equal to the work done on or by the system.
6. Power is the rate of energy transfer into or out of a system.
7. Changes within the nucleus of an atom result in the release of energy.
8. In nuclear processes such as nuclear decay, fission and fusion, the mass of the product is less than the mass of the original nuclei.
9. The transfer of energy out of a system is directly proportional to the change in mass of the system as expressed by E = mc2.

Skills

**Bloom's Taxonomy/DOK**

**Remember (Level 1)**

1. Identify questions and concepts that guide scientific investigations.

Use technology and mathematics to improve investigations and communications.

**Understand (Levels 1 and 2)**

1. Quantitatively determine the amount of kinetic, elastic, gravitational energy in systems.
2. Apply the Law of Conservation of Energy to situations to find changes in energy of systems.

**Analyze (Level 3)**

1. Analyze situations and determine where energy is stored (kinetic, elastic, gravitational, chemical or internal) and transferred into or out of systems.
2. Use technology and mathematics to improve investigations and communications.
3. Recognize and analyze explanations and models.

**Evaluate (Levels 3 and 4)**

1. Communicate and defend a scientific argument.
2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).

**Create (Level 4)**

1. Design experiments to find the relationships between quantifiable variables.
2. Create graphs from experimental data and derive mathematical relationships between variables (models).
3. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
4. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

Essential Questions

1. How do we measure stored energy?
2. How do we measure moving energy?
3. How is energy transferred?
4. What is work? How is it measured?
5. What is power? How is it measured?

Stage 2: Assessment Evidence

Energy Transfer Lab 1

Formative: Lab Assignment

Using springs to launch dynamics carts, students calculate the amount of energy stored in the launch spring and find the maximum velocity of the cart. By graphing spring energy vs. the square maximum velocity, students will learn that the slope of the graph is equal to 1/2 mass of the system and can equate the transfer of energy stored within the spring (elastic) to energy stored within the cart (kinetic). The lab requires the use of Vernier or Pasco dynamics carts and tracks and motion detectors or photogates.

Energy Transfer Lab 2

Formative: Lab Assignment

Using the same apparatus in the Energy Transfer Lab 1, students are asked to slightly incline the ramp and measure the maximum height the cart reaches. If students graph the amount of energy stored in the spring vs. maximum cart height, they will see a direct relationship between spring energy and maximum cart height. Analysis of the slope of the graph by students will show that it is equal to the gravitational force (weight) on the cart.

Energy Transfer & Power Lab

Formative: Lab Assignment

Students distinguish energy and power by contrasting situations where energy transfer is the same but the transfer is done at different rates. Students should calculate the amount of energy transferred by walking or running up a flight of stairs and then compute the power for each situation.

Homework

Formative: Homework

Students may use readings, writings, questions and problems to practice concepts.

Quizzes

Formative: Quiz

Quizzes are used to gauge the progress of student understanding of learning content and skills.

Unit Test

Summative: Test

Students may take a Unit Test to demonstrate understanding.

Hooke's Law Lab

Formative: Lab Assignment

Students use springs to quantify elastic potential energy. Through graphing force used to stretch spring vs. amount of stretch, students learn what spring constant represents. Once Hooke's Law has been developed, students can be introduced to the idea that the energy stored within a spring is area under the force versus displacement graph.

Resources

Stage 3: Learning Plan

Learning Experiences

1. Guided Inquiry
2. Cooperative Learning Groups
3. Socratic Seminar
4. Small Group and Class Discussions
5. Direct Instruction
6. Critical Thinking

Technology Integration

1. SmartBoard
2. Smart phone
3. Computers Internet
4. Graphing software (Excel, LoggerPro)
5. Vernier software and hardware
6. Pasco software and hardware
7. Video analysis software

Resources

Resources

**Books**

1. O'Kuma,T. L., Maloney, D. P., Hieggelke, C. J. (2003). *Ranking task exercises in physics.* New York: Addison-Wesley.

**YouTube**

1. MinutePhysics videos provide concise and amusing explanations for many physics topics.

Resources

* Hippo Campus (<http://www.hippocampus.org/HippoCampus/Physics>)

Grades 9-12 Science
Physics

Momentum and Impulse

Stage 1: Desired Results

Catholic Standards

DOC All Grades DOC: Catholic Standards

The Profession of Faith

Students will be able to

1. Recognize God in the world's order, beauty, and goodness (CCC 32).

Life in Christ

Students will be able to

2. Know that we must assume responsibility for the acts we perform (CCC 1781).

12. Respect the integrity of all creation, including animals, plants, and all nature (CCC 2415).

Targeted Standards

NGSS Grade 2 NGSS: Disciplinary Core Ideas

ETS1: Engineering Design

Defining and Delimiting an Engineering Problem

A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. (K-2-ETS1- 1) (secondary to KPS2-2)

NGSS Grade 9-12 NGSS: Crosscutting Concepts

Crosscutting Statements

Patterns Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

NGSS Grade 9-12 NGSS: Science and Engineering Practices

Practice 8. Obtaining, evaluating, and communicating information

Obtaining, evaluating, and communicating information in 912 builds on K8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.

Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Practice 6. Constructing explanations (for science) and designing solutions (for engineering)

Constructing explanations and designing solutions in 912 builds on K8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.

Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Practice 7. Engaging in argument from evidence

Engaging in argument from evidence in 912 builds on K8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.

Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Practice 1. Asking questions (for science) and defining problems (for engineering)

Asking questions and defining problems in 912 builds on K8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.

Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.

Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.

Ask questions to clarify and refine a model, an explanation, or an engineering problem.

Evaluate a question to determine if it is testable and relevant.

Practice 2. Developing and using models

Modeling in 912 builds on K8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria.

Design a test of a model to ascertain its reliability.

Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.

Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Practice 3. Planning and carrying out investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigations design to ensure variables are controlled.

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.

Select appropriate tools to collect, record, analyze, and evaluate data.

Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.

Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

Practice 4. Analyzing and interpreting data

Analyzing data in 912 builds on K8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.

Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.

Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.

Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.

Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

OH Grade 9-12 OH: Science (2011)

HS Physics

Science Inquiry and Application During the years of grades 9 through 12 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

Identify questions and concepts that guide scientific investigations;

Design and conduct scientific investigations;

Use technology and mathematics to improve investigations and communications;

Formulate and revise explanations and models using logic and evidence (critical thinking);

Recognize and analyze explanations and models

Communicate and defend a scientific argument.

Course Content: Forces, momentum and motion

Newtons laws applied to complex problems

Momentum, impulse and conservation of momentum

OH Grades 11-12 OH: Literacy in History/Social Studies, Science, & Technical Subjects 6-12

Writing

Text Types and Purposes 1. Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence.

WHST.11-12.1. Write arguments focused on discipline-specific content.

WHST.11-12.1a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.

WHST.11-12.1b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audiences knowledge level, concerns, values, and possible biases.

WHST.11-12.1c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.

WHST.11-12.1d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

WHST.11-12.1e. Provide a concluding statement or section that follows from or supports the argument presented.

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

WHST.11-12.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

WHST.11-12.2a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.

WHST.11-12.2b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audiences knowledge of the topic.

WHST.11-12.2c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.

WHST.11-12.2d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.

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8. THE RIGHT TO LEARN RESPONSIBILITY for themselves and their actions.

9. THE RIGHT TO MAKE RESPONSIBLE DECISIONS founded on religious conviction.

Summary

Students are introduced to the notion of momentum as a vector and that forces acting on systems create changes in momentum. Collisions are analyzed to determine conserved quantities (momentum and kinetic energy).

Unit Goals

1. Students will understand how to determine the momentum of a system and see that slow massive objects can have the same momentum as low-mass fast objects.
2. Students will understand that changes in momentum of systems are caused by impulses acting on them.
3. Students will understand the notion of conservation of momentum in closed systems to predict motion.

Big Ideas

1. Moving objects have a quantity of motion that is conserved when objects interact in closed systems.

Enduring Understandings

1. All moving objects have momentum which can be quantified.
2. Slow massive objects can have the same momentum as low-mass fast objects.
3. A closed system is one where no mass is transferred into or out of a system and isn't subject to any force whose source is external to the system.
4. Momentum is conserved when objects interact in closed systems.
5. The same change in momentum can be caused by a large force applied over a short time period or a small force applied over a long time period.

Content

1. Momentum is the product of an object's velocity and mass.
2. Momentum is a vector.
3. Impulse is a product of the net external force acting on a system and the period of time for which it acts.
4. Impulses acting on a system cause change in its momentum.
5. Impulse equals the area under a force-time graph.
6. There is a difference between elastic and inelastic collisions and the quantities conserved in each.
7. A closed system is one where matter is not exchanged between the system and its surroundings and isn't subject to any force whose source is external to the system.
8. Momentum is conserved during interactions within a closed system.

Skills

**Bloom's Taxonomy/DOK**

**Remember (Level 1)**

1. Calculate the momentum of objects and systems.
2. Use graphs of force and time to determine the impulse acting on a system.
3. Identify questions and concepts that guide scientific investigations.
4. Use technology and mathematics to improve investigations and communications.
5. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

**Understand (Levels 1 and 2)**

1. Find the impulse acting on a system by determining its change in momentum.
2. Find the change in momentum of a system by determining the impulse.
3. Differentiate between elastic and inelastic collisions.
4. Predict motion before or after object interactions.

**Analyze (Level 3)**

1. Formulate and revise explanations and models using logic and evidence (critical thinking).
2. Recognize and analyze explanations and models.

**Evaluate (Levels 3 and 4)**

1. Communicate and defend a scientific argument.

**Create (Level 4)**

1. Design experiments to find the relationships between quantifiable variables.
2. Create graphs from experimental data and derive mathematical relationships between variables (models).
3. Design and conduct scientific investigations.

Essential Questions

1. How do we measure momentum?
2. What is momentum?
3. How can momentum be changed?
4. What causes a change in momentum?
5. What is impulse?
6. Why do airbags reduce injuries during collisions?
7. What happens to momentum during interactions between objects?

Stage 2: Assessment Evidence

Cart Explosions Lab

Formative: Lab Assignment

Using two dynamics carts (one with a plunger), a track and extra masses, students develop the idea of conservation of momentum. This is accomplished by having the plunger separate the carts and having the students graph the ratio of the cart masses vs. the ratio of the velocities. The graphs of the ratios should yield a straight line indicating that the product of the mass and velocity of each are the same.

Impulse and Change in Momentum Lab

Formative: Lab Assignment

Using a dynamics cart, a hoop spring attached to a force sensor, and a motion sensor or photogates, students should see that the impulse acting on the cart is equal to the change in the cart's momentum. This is accomplished by having the cart collide with the hoop spring and force sensor and measuring the change in velocity. This can also be done as a demonstration.

Collisions Lab

Formative: Lab Assignment

Using dynamics carts, masses, and motion sensors or photogates, students learn that momentum is conserved during different kinds of collisions, but energy is only conserved in elastic collisions.

Homework

Formative: Homework

Students can use readings, writings, questions and problems to practice concepts.

Quizzes

Formative: Quiz

Quizzes are used to gauge the progress of student understanding of learning content and skills.

Unit Test

Summative: Test

Students may take a Unit Test to demonstrate understanding.

Stage 3: Learning Plan

Learning Experiences

1. Guided Inquiry
2. Cooperative Learning Groups
3. Socratic Seminar
4. Small Group and Class Discussions
5. Direct Instruction
6. Critical Thinking

Technology Integration

1. SmartBoard
2. Smart phone
3. Computers Internet
4. Graphing software (Excel, LoggerPro)
5. Vernier software and hardware
6. Pasco software and hardware
7. Video analysis software

Resources

**Books**

1. O'Kuma,T. L., Maloney, D. P., Hieggelke, C. J. (2003). *Ranking task exercises in physics.* New York: Addison-Wesley.

**YouTube**

1. MinutePhysics videos provide concise and amusing explanations for many physics topics.

Resources

* Physics Classroom (<http://www.physicsclassroom.com/>)

Grades 9-12 Science
Physics

Mechanical Waves

Stage 1: Desired Results

Catholic Standards

DOC All Grades DOC: Catholic Standards

The Profession of Faith

Students will be able to

1. Recognize God in the world's order, beauty, and goodness (CCC 32).

Life in Christ

Students will be able to

2. Know that we must assume responsibility for the acts we perform (CCC 1781).

12. Respect the integrity of all creation, including animals, plants, and all nature (CCC 2415).

Targeted Standards

NGSS Grade 2 NGSS: Disciplinary Core Ideas

ETS1: Engineering Design

Defining and Delimiting an Engineering Problem

A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. (K-2-ETS1- 1) (secondary to KPS2-2)

NGSS Grade 9-12 NGSS: Crosscutting Concepts

Crosscutting Statements

Patterns Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

NGSS Grade 9-12 NGSS: Science and Engineering Practices

Practice 8. Obtaining, evaluating, and communicating information

Obtaining, evaluating, and communicating information in 912 builds on K8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.

Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Practice 6. Constructing explanations (for science) and designing solutions (for engineering)

Constructing explanations and designing solutions in 912 builds on K8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.

Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Practice 7. Engaging in argument from evidence

Engaging in argument from evidence in 912 builds on K8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.

Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Practice 1. Asking questions (for science) and defining problems (for engineering)

Asking questions and defining problems in 912 builds on K8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.

Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.

Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.

Ask questions to clarify and refine a model, an explanation, or an engineering problem.

Evaluate a question to determine if it is testable and relevant.

Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.

Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.

Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and/or environmental considerations.

Practice 2. Developing and using models

Modeling in 912 builds on K8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria.

Design a test of a model to ascertain its reliability.

Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.

Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Practice 3. Planning and carrying out investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigations design to ensure variables are controlled.

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.

Select appropriate tools to collect, record, analyze, and evaluate data.

Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.

Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

Practice 4. Analyzing and interpreting data

Analyzing data in 912 builds on K8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.

Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.

Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.

Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.

Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Practice 5. Using mathematics and computational thinking

Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Apply techniques of algebra and functions to represent and solve scientific and engineering problems.

Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model makes sense by comparing the outcomes with what is known about the real world.

Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).

OH Grade 9-12 OH: Science (2011)

HS Physics

Science Inquiry and Application During the years of grades 9 through 12 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

Identify questions and concepts that guide scientific investigations;

Design and conduct scientific investigations;

Use technology and mathematics to improve investigations and communications;

Formulate and revise explanations and models using logic and evidence (critical thinking);

Recognize and analyze explanations and models

Communicate and defend a scientific argument.

Course Content: Waves

Wave properties: Conservation of energy

Wave properties: Reflection

Wave properties: Refraction

Wave properties: Interference

Wave properties: Diffraction

OH Grades 11-12 OH: Literacy in History/Social Studies, Science, & Technical Subjects 6-12

Writing

Text Types and Purposes 1. Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence.

WHST.11-12.1. Write arguments focused on discipline-specific content.

WHST.11-12.1a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.

WHST.11-12.1b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audiences knowledge level, concerns, values, and possible biases.

WHST.11-12.1c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.

WHST.11-12.1d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

WHST.11-12.1e. Provide a concluding statement or section that follows from or supports the argument presented.

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

WHST.11-12.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

WHST.11-12.2a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.

WHST.11-12.2b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audiences knowledge of the topic.

WHST.11-12.2c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.

WHST.11-12.2d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.

WHST.11-12.2e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).

Production and Distribution of Writing 4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

WHST.11-12.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.

WHST.11-12.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

WHST.11-12.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

Research to Build and Present Knowledge 7. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

WHST.11-12.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.

WHST.11-12.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

Draw evidence from literary or informational texts to support analysis, reflection, and research.

WHST.11-12.9. Draw evidence from informational texts to support analysis, reflection, and research.

Range of Writing 10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

WHST.11-12.10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Reading: Science & Technical Subjects

Key Ideas and Details 1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

RST.11-12.1. Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.

RST.11-12.2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Analyze how and why individuals, events, or ideas develop and interact over the course of a text.

RST.11-12.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

Craft and Structure 4. Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

RST.11-12.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 1112 texts and topics.

Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole.

RST.11-12.5. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.

Assess how point of view or purpose shapes the content and style of a text.

RST.11-12.6. Analyze the authors purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.

Integration of Knowledge and Ideas 7. Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.

RST.11-12.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.

RST.11-12.8. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

RST.11-12.9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Read and comprehend complex literary and informational texts independently and proficiently.

RST.11-12.10. By the end of grade 12, read and comprehend science/technical texts in the grades 1112 text complexity band independently and proficiently.

Capacities of the Literate Individual

Students Who are College and Career Ready in Reading, Writing, Speaking, Listening, & Language

They demonstrate independence.

Catholic Identity

DOC All Grades Catholic Identity

Catholic Social Justice Teachings

Life and Dignity of the Human Person

Rights and Responsibilities

The Dignity of Work and the Rights of Workers

Call to Family, Community, and Participation

Option for the Poor and Vulnerable

Solidarity

Care for God's Creation

The Rights of Children

1. THE RIGHT TO A CATHOLIC COMMUNITY that witnesses to Christ and the Gospel by protecting them from child abuse, including sexual abuse and neglect.

2. THE RIGHT TO A SAFE ENVIRONMENT that promotes care, protection, and security.

3. THE RIGHT TO BE RESPECTED AS INDIVIDUALS with human dignity.

4. THE RIGHT TO WORK ACTIVELY TOWARD THEIR OWN EMPOWERMENT through the development of their gifts and talents.

5. THE RIGHT TO A LEARNING ENVIRONMENT THAT VALUES COOPERATION and challenges its members to critical and reflective thinking in their search for truth.

6. THE RIGHT TO DEVELOP POSITIVE, RESPONSIBLE AND CARING ATTITUDES AND BEHAVIORS TOWARD OTHERS and to recognize the rights of others to be safe and free from harassment and abuse.

8. THE RIGHT TO LEARN RESPONSIBILITY for themselves and their actions.

9. THE RIGHT TO MAKE RESPONSIBLE DECISIONS founded on religious conviction.

Summary

Students are introduced to the idea that a wave is a transfer of energy between two points. Waves can be characterized by measurable properties and interfere with each other when propagating.

Unit Goals

1. Students will understand that waves are transfers of energy through mediums and can be characterized by measurable properties such as frequency, wavelength, and time.
2. Students will understand that as waves propagate, they can interfere with other waves destructively and constructively.
3. Students will understand that when waves encounter obstacles or small openings, they tend to bend or refract.

Big Ideas

1. All waves, regardless of origin or type, transmit energy from one place to another and share a common set of characteristics that explain their behavior.

Enduring Understandings

1. Waves are disturbances that transport energy, not matter.
2. Mechanical waves require a medium.
3. The interference of waves can cause standing waves.
4. When waves move from one medium to another, energy is conserved.

Content

1. Waves transfer energy without the transfer of matter.
2. Mechanical waves need a medium; electromagnetic waves do not.
3. In transverse waves, the particles of the medium move perpendicularly to the direction of the wave, and in longitudinal waves, the particles move parallel to the wave direction.
4. Measurable properties of waves, such as wavelength, frequency and amplitude, are used to mathematically describe the behavior of waves.
5. The amount of bending of waves around barriers or small openings (diffraction) increases with decreasing wavelength, but when the wavelength is smaller than the obstacle or opening, no noticeable diffraction occurs.
6. As waves pass through single or double slits, diffraction patterns are created with alternating lines of constructive and destructive interference.
7. Constructive wave interference results in increases in wave amplitude, and destructive interference results in diminished amplitudes.

Skills

**Bloom's Taxonomy/DOK**

**Remember (Level 1)**

1. Define a "wave" as a periodic disturbance and differentiate between mechanical and electromagnetic waves.
2. Define transverse and longitudinal waves and provide examples of each.
3. Identify questions and concepts that guide scientific investigations.
4. Use technology and mathematics to improve investigations and communications.
5. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

**Understand (Levels 1 and 2)**

1. Explain the relationship between the period, frequency, speed and wavelength of a wave.
2. Explain the principle of superposition and its relationship to wave interference.
3. Calculate the period, frequency, speed, and wavelength of a wave.

**Analyze (Level 3)**

1. Formulate and revise explanations and models using logic and evidence (critical thinking).

Recognize and analyze explanations and models.

**Evaluate (Levels 3 and 4)**

1. Communicate and defend a scientific argument.

**Create (Level 4)**

Design and conduct scientific investigations.

Essential Questions

1. What are waves?
2. Are there different kinds of waves?
3. How do waves move through a medium?
4. How do musical instruments work?
5. What properties of waves can be measured?
6. What happens when waves interact?
7. What happens to the energy of a wave when it moves from one medium to another?
8. What happens to a wave when it changes media or encounters obstacles?

Stage 2: Assessment Evidence

Wave Properties with Super Slinkies

Formative: Lab Assignment

Using super slinkies, stopwatches, and meter sticks or tape measures, students develop understanding of core wave phenomena through manipulation of slinky waves; they also discover the key concept of wave speed being determined by the medium. See included handout.

Waves Encountering Boundaries

Formative: Lab Assignment

Using super slinkies, long tight coiled (brass) springs, stopwatches, meter sticks or tape measures and student smartphone cameras for video analysis, students discover the wave equation (v=f) and many properties of waves when striking an interface and changing materials. See attached document.

Ripple Tank Lab

Formative: Lab Assignment

Students use ripple tanks to observe wave phenomena such as interference, reflection and diffraction. See attached documents.

Homework

Formative: Homework

Students may use readings, writings, questions and problems to review concepts.

Quizzes

Formative: Quiz

Quizzes are used to gauge the progress of student understanding of learning content and skills.

Unit Test

Summative: Test

Students may take a Unit Test to demonstrate understanding.

Resources

Stage 3: Learning Plan

Learning Experiences

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3. Socratic Seminar
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Technology Integration

1. SmartBoard
2. Smart phone
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4. Graphing software (Excel, LoggerPro)
5. Vernier software and hardware
6. Pasco software and hardware
7. Video analysis software

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Resources

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**YouTube**

1. MinutePhysics videos provide concise and amusing explanations for many physics topics.

Resources

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Grades 9-12 Science
Physics

Light

Stage 1: Desired Results

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DOC All Grades DOC: Catholic Standards

The Profession of Faith

Students will be able to

1. Recognize God in the world's order, beauty, and goodness (CCC 32).

Life in Christ

Students will be able to

2. Know that we must assume responsibility for the acts we perform (CCC 1781).

12. Respect the integrity of all creation, including animals, plants, and all nature (CCC 2415).

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Defining and Delimiting an Engineering Problem

A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. (K-2-ETS1- 1) (secondary to KPS2-2)

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Crosscutting Statements

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Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.

Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Practice 6. Constructing explanations (for science) and designing solutions (for engineering)

Constructing explanations and designing solutions in 912 builds on K8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.

Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Practice 7. Engaging in argument from evidence

Engaging in argument from evidence in 912 builds on K8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.

Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Practice 1. Asking questions (for science) and defining problems (for engineering)

Asking questions and defining problems in 912 builds on K8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.

Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.

Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.

Ask questions to clarify and refine a model, an explanation, or an engineering problem.

Evaluate a question to determine if it is testable and relevant.

Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.

Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.

Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and/or environmental considerations.

Practice 2. Developing and using models

Modeling in 912 builds on K8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria.

Design a test of a model to ascertain its reliability.

Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.

Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Practice 3. Planning and carrying out investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigations design to ensure variables are controlled.

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.

Select appropriate tools to collect, record, analyze, and evaluate data.

Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.

Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

Practice 4. Analyzing and interpreting data

Analyzing data in 912 builds on K8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.

Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.

Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.

Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.

Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Practice 5. Using mathematics and computational thinking

Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Apply techniques of algebra and functions to represent and solve scientific and engineering problems.

Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model makes sense by comparing the outcomes with what is known about the real world.

Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).

OH Grade 9-12 OH: Science (2011)

HS Physics

Science Inquiry and Application During the years of grades 9 through 12 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

Identify questions and concepts that guide scientific investigations;

Design and conduct scientific investigations;

Use technology and mathematics to improve investigations and communications;

Formulate and revise explanations and models using logic and evidence (critical thinking);

Recognize and analyze explanations and models

Communicate and defend a scientific argument.

Course Content: Waves

Wave properties: Conservation of energy

Wave properties: Reflection

Wave properties: Refraction

Wave properties: Interference

Wave properties: Diffraction

Light phenomena: Ray diagrams (propagation of light)

Light phenomena:Law of reflection (equal angles)

Light phenomena: Snells law

Light phenomena: Diffraction patterns

Light phenomena: Wave particle duality of light

Light phenomena: Visible spectrum and color

OH Grades 11-12 OH: Literacy in History/Social Studies, Science, & Technical Subjects 6-12

Writing

Text Types and Purposes 1. Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence.

WHST.11-12.1. Write arguments focused on discipline-specific content.

WHST.11-12.1a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.

WHST.11-12.1b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audiences knowledge level, concerns, values, and possible biases.

WHST.11-12.1c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.

WHST.11-12.1d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

WHST.11-12.1e. Provide a concluding statement or section that follows from or supports the argument presented.

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

WHST.11-12.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

WHST.11-12.2a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.

WHST.11-12.2b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audiences knowledge of the topic.

WHST.11-12.2c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.

WHST.11-12.2d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.

WHST.11-12.2e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).

Production and Distribution of Writing 4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

WHST.11-12.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.

WHST.11-12.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

WHST.11-12.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

Research to Build and Present Knowledge 7. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

WHST.11-12.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.

WHST.11-12.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

Draw evidence from literary or informational texts to support analysis, reflection, and research.

WHST.11-12.9. Draw evidence from informational texts to support analysis, reflection, and research.

Range of Writing 10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

WHST.11-12.10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Reading: Science & Technical Subjects

Key Ideas and Details 1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

RST.11-12.1. Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.

RST.11-12.2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Analyze how and why individuals, events, or ideas develop and interact over the course of a text.

RST.11-12.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

Craft and Structure 4. Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

RST.11-12.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 1112 texts and topics.

Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole.

RST.11-12.5. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.

Assess how point of view or purpose shapes the content and style of a text.

RST.11-12.6. Analyze the authors purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.

Integration of Knowledge and Ideas 7. Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.

RST.11-12.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.

RST.11-12.8. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

RST.11-12.9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Read and comprehend complex literary and informational texts independently and proficiently.

RST.11-12.10. By the end of grade 12, read and comprehend science/technical texts in the grades 1112 text complexity band independently and proficiently.

OH Grades 6-8 OH: Literacy in History/Social Studies, Science, & Technical Subjects 6-12

Capacities of the Literate Individual

Students Who are College and Career Ready in Reading, Writing, Speaking, Listening, & Language

They demonstrate independence.

Catholic Identity

DOC All Grades Catholic Identity

Catholic Social Justice Teachings

Life and Dignity of the Human Person

Rights and Responsibilities

The Dignity of Work and the Rights of Workers

Call to Family, Community, and Participation

Option for the Poor and Vulnerable

Solidarity

Care for God's Creation

The Rights of Children

1. THE RIGHT TO A CATHOLIC COMMUNITY that witnesses to Christ and the Gospel by protecting them from child abuse, including sexual abuse and neglect.

2. THE RIGHT TO A SAFE ENVIRONMENT that promotes care, protection, and security.

3. THE RIGHT TO BE RESPECTED AS INDIVIDUALS with human dignity.

4. THE RIGHT TO WORK ACTIVELY TOWARD THEIR OWN EMPOWERMENT through the development of their gifts and talents.

5. THE RIGHT TO A LEARNING ENVIRONMENT THAT VALUES COOPERATION and challenges its members to critical and reflective thinking in their search for truth.

6. THE RIGHT TO DEVELOP POSITIVE, RESPONSIBLE AND CARING ATTITUDES AND BEHAVIORS TOWARD OTHERS and to recognize the rights of others to be safe and free from harassment and abuse.

8. THE RIGHT TO LEARN RESPONSIBILITY for themselves and their actions.

9. THE RIGHT TO MAKE RESPONSIBLE DECISIONS founded on religious conviction.

Summary

Students are introduced to the idea that the behavior and properties of light waves are taught in relation to light's place within the range of the electromagnetic spectrum. The inquiry into the mechanics of light is centered around the mathematical modeling of light as rays. The mathematical ray model for light is shown to behave like a system by the application of the laws of reflection and refraction and Snell's law. Principles of Optics are investigated by extending the ray model of light.

Unit Goals

1. Students will understand that visible light is a fraction of the electromagnetic spectrum.
2. Students will understand how a polarizing filter works.
3. Students will know that light has a constant speed in a vacuum.
4. Students will understand how color is perceived and be able to evaluate which model of light is appropriate to predict light phenomenon (particle or wave).
5. Students will be able to use angle inangle out to predict specular reflection and use Snell's Law to predict the angle of light refraction in transparent media.

Big Ideas

1. Electromagnetic waves transfer energy and information from place to place without a material medium, and visible light is a form of electromagnetic radiation.
2. All electromagnetic waves move at the speed of light in a vacuum.
3. Light can be explained both as a particle and a wave.

Enduring Understandings

1. Light does not require a medium to transfer energy.
2. Visible light is a small fraction of the E-M spectrum.
3. The path of light can be represented by a ray.
4. The behavior of light can be modeled as a particle or a wave.

Content

1. The path of light waves can be represented with ray diagrams.
2. Light rays obey the law of reflection and Snell's Law.
3. The index of refraction of a medium is a ratio of the speed of light in a vacuum and its speed in the medium.
4. Light rays traveling through slits result in alternating patterns of light and dark due to wave interference and the patterns are directly related to spacing of the slits.
5. There are two models of how radiant energy travels through space at the speed of light:

One model is that the radiation travels in discrete packets of energy called photons that are continuously emitted from an object in all directions. The energy of these photons is directly proportional to the frequency of the electromagnetic radiation.

A second model is that radiant energy travels like a wave that spreads out in all directions from a source.

1. Humans can only perceive a very narrow portion of the electromagnetic spectrum.
2. Radiant energy from the sun or a light bulb filament is a mixture of all the colors of light (visible light spectrum). The different colors correspond to different radiant energies.
3. When white light hits an object, the pigments in the object reflect one or more colors in all directions and absorb the other colors.
4. When waves bounce off barriers (reflection), the angle at which a wave approaches the barrier (angle of incidence) equals the angle at which the wave reflects off the barrier (angle of reflection).
5. When a wave travels from a two-dimensional (e.g., surface water, seismic waves) or three- dimensional (e.g., sound, electromagnetic waves) medium into another medium in which the wave travels at a different speed, both the speed and the wavelength of the transferred wave change.
6. Depending on the angle between the wave and the boundary with which it is interacting, the direction of the wave also can change resulting in refraction.

Skills

**Bloom's Taxonomy/DOK**

**Remember (Level 1)**

1. Draw ray diagrams to indicate how light reflects off objects or refracts through transparent media.
2. Calculate the index of refraction of materials.
3. Given an angle of incidence and indices of refraction of two materials, calculate the path of a light ray incident on the boundary (Snells Law).
4. Identify questions and concepts that guide scientific investigations.
5. Use technology and mathematics to improve investigations and communications.
6. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

**Understand (Levels 1 and 2)**

1. Predict patterns of destructive and constructive interference as light travels through slits.
2. Apply the law of reflection to predict image formation of plane mirrors.

**Analyze (Level 3)**

1. Formulate and revise explanations and models using logic and evidence (critical thinking).
2. Recognize and analyze explanations and models.

**Evaluate (Levels 3 and 4)**

1. Communicate and defend a scientific argument.
2. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

**Create (Level 4)**

1. Design and conduct scientific investigations.

Essential Questions

1. What is light?
2. How do polarized sunglasses work?
3. How fast does light move in a vacuum?
4. How is color perceived?
5. Does light act like a wave?
6. How do mirrors work?
7. Why do objects appear to be in different locations when underwater?

Stage 2: Assessment Evidence

KWL Chart

Diagnostic: Self Assessment

Before beginning a unit, students discuss what they already know about the topic and what they expect to learn.

Teacher Directed Reading

Formative: Reading Task

Teacher assigns reading appropriate to unit which may come from textbook or sources such as Scientific American or articles from Ebsco Host through INFOhio.

In Class Work

Formative: Cooperative Group Work

Students can work in groups on tasks. Application of new equations is aided by working in groups.

Mirror, Mirror Lab from IIT/Field Museum (Chicago)

Formative: Lab Assignment

Mirror, Mirror is a variation of the PSSC plane mirror lab. It includes student direction pages as well as teacher answer key.

Refraction Labs

Formative: Lab Assignment

The attached document contains five small activities that could be used as one lab or mini stations around the room. Both qualitative and quantitative observations are made and used along with practice on Snell's Law.

Puzzling Polarizers

Formative: Lab Assignment

The attached link contains two practical activities using polarized sunglasses and polarizing film. It was taken from Advanced Light Source, Adventures in Light Science Teacher Workshop, March 1996.

Additive Colors

Formative: Lab Assignment

This activity can be used as a simple demonstration or experiment. It creates white light from three flashlights with colored filters. Some students may never have seen this first hand, so it is included if it has not been part of their background knowledge. Students can also perform virtual lab using link (Phet) below.

Additive Colors In Depth

Formative: Lab Assignment

The attached link contains a few more additive color labs. You will need more equipment; sources are included for where to find it if you don't already have the materials.

Snell's Law Lab

Formative: Lab Assignment

Students should direct a laser into an acrylic prism. Students should measure angle of incidence and angle of refraction and plot the sine of angle, the incidence angle on the y axis, and the sine of the refractive angle on the x axis. Students should find that the slope of the graph is constant and is equal to the refractive index of acrylic. See attached document. Students can also perfom lab virtually using link below.

Homework

Formative: Homework

Students can complete readings, writings, questions and problems to practice concepts.

Unit Test

Summative: Test

Teacher designed, unit-appropriate tests may be given at the end of the unit.

Resources

Stage 3: Learning Plan

Learning Experiences

1. Guided Inquiry
2. Cooperative Learning Groups
3. Socratic Seminar
4. Small Group and Class Discussions
5. Direct Instruction
6. Critical Thinking

Technology Integration

1. SmartBoard
2. Smart phone
3. Computers Internet
4. Graphing software (Excel, LoggerPro)
5. Vernier software and hardware
6. Pasco software and hardware
7. Video analysis software

Resources

Resources

**Books**

1. O'Kuma,T. L., Maloney, D. P., Hieggelke, C. J. (2003). *Ranking task exercises in physics.* New York: Addison-Wesley.

**YouTube**

1. MinutePhysics videos provide concise and amusing explanations for many physics topics.

Resources

* The Physics Classroom (<http://www.physicsclassroom.com/>)

Grades 9-12 Science
Physics

Electrical Fields and Forces

Stage 1: Desired Results

Catholic Standards

DOC All Grades DOC: Catholic Standards

The Profession of Faith

Students will be able to

1. Recognize God in the world's order, beauty, and goodness (CCC 32).

Life in Christ

Students will be able to

2. Know that we must assume responsibility for the acts we perform (CCC 1781).

7. Assume personal responsibility (CCC 1914).

12. Respect the integrity of all creation, including animals, plants, and all nature (CCC 2415).

Targeted Standards

NGSS Grade 2 NGSS: Disciplinary Core Ideas

ETS1: Engineering Design

Defining and Delimiting an Engineering Problem

A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. (K-2-ETS1- 1) (secondary to KPS2-2)

NGSS Grade 9-12 NGSS: Crosscutting Concepts

Crosscutting Statements

Patterns Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

NGSS Grade 9-12 NGSS: Science and Engineering Practices

Practice 8. Obtaining, evaluating, and communicating information

Obtaining, evaluating, and communicating information in 912 builds on K8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.

Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Practice 6. Constructing explanations (for science) and designing solutions (for engineering)

Constructing explanations and designing solutions in 912 builds on K8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.

Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Practice 7. Engaging in argument from evidence

Engaging in argument from evidence in 912 builds on K8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.

Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Practice 1. Asking questions (for science) and defining problems (for engineering)

Asking questions and defining problems in 912 builds on K8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.

Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.

Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.

Ask questions to clarify and refine a model, an explanation, or an engineering problem.

Evaluate a question to determine if it is testable and relevant.

Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.

Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.

Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and/or environmental considerations.

Practice 2. Developing and using models

Modeling in 912 builds on K8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria.

Design a test of a model to ascertain its reliability.

Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.

Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Practice 3. Planning and carrying out investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigations design to ensure variables are controlled.

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.

Select appropriate tools to collect, record, analyze, and evaluate data.

Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.

Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

Practice 4. Analyzing and interpreting data

Analyzing data in 912 builds on K8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.

Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.

Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.

Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.

Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Practice 5. Using mathematics and computational thinking

Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Apply techniques of algebra and functions to represent and solve scientific and engineering problems.

Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model makes sense by comparing the outcomes with what is known about the real world.

Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).

OH Grade 9-12 OH: Science (2011)

HS Physics

Science Inquiry and Application During the years of grades 9 through 12 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

Identify questions and concepts that guide scientific investigations;

Design and conduct scientific investigations;

Use technology and mathematics to improve investigations and communications;

Formulate and revise explanations and models using logic and evidence (critical thinking);

Recognize and analyze explanations and models

Communicate and defend a scientific argument.

Course Content: Forces, momentum and motion

Forces in two dimensions: Adding vector forces

Course Content: Electricity and magnetism

Charging objects (friction, contact and induction)

Coulombs law

Electric fields and electric potential energy

OH Grades 11-12 OH: Literacy in History/Social Studies, Science, & Technical Subjects 6-12

Writing

Text Types and Purposes 1. Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence.

WHST.11-12.1. Write arguments focused on discipline-specific content.

WHST.11-12.1a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.

WHST.11-12.1b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audiences knowledge level, concerns, values, and possible biases.

WHST.11-12.1c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.

WHST.11-12.1d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

WHST.11-12.1e. Provide a concluding statement or section that follows from or supports the argument presented.

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

WHST.11-12.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

WHST.11-12.2a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.

WHST.11-12.2b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audiences knowledge of the topic.

WHST.11-12.2c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.

WHST.11-12.2d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.

WHST.11-12.2e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).

Production and Distribution of Writing 4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

WHST.11-12.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.

WHST.11-12.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

WHST.11-12.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

Research to Build and Present Knowledge 7. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

WHST.11-12.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.

WHST.11-12.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

Draw evidence from literary or informational texts to support analysis, reflection, and research.

WHST.11-12.9. Draw evidence from informational texts to support analysis, reflection, and research.

Range of Writing 10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

WHST.11-12.10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Reading: Science & Technical Subjects

Key Ideas and Details 1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

RST.11-12.1. Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.

RST.11-12.2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Analyze how and why individuals, events, or ideas develop and interact over the course of a text.

RST.11-12.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

Craft and Structure 4. Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

RST.11-12.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 1112 texts and topics.

Assess how point of view or purpose shapes the content and style of a text.

RST.11-12.6. Analyze the authors purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.

Integration of Knowledge and Ideas 7. Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.

RST.11-12.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.

RST.11-12.8. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

RST.11-12.9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Capacities of the Literate Individual

Students Who are College and Career Ready in Reading, Writing, Speaking, Listening, & Language

They demonstrate independence.

Catholic Identity

DOC All Grades Catholic Identity

Catholic Social Justice Teachings

Life and Dignity of the Human Person

Rights and Responsibilities

The Dignity of Work and the Rights of Workers

Call to Family, Community, and Participation

Option for the Poor and Vulnerable

Solidarity

Care for God's Creation

The Rights of Children

1. THE RIGHT TO A CATHOLIC COMMUNITY that witnesses to Christ and the Gospel by protecting them from child abuse, including sexual abuse and neglect.

2. THE RIGHT TO A SAFE ENVIRONMENT that promotes care, protection, and security.

3. THE RIGHT TO BE RESPECTED AS INDIVIDUALS with human dignity.

4. THE RIGHT TO WORK ACTIVELY TOWARD THEIR OWN EMPOWERMENT through the development of their gifts and talents.

5. THE RIGHT TO A LEARNING ENVIRONMENT THAT VALUES COOPERATION and challenges its members to critical and reflective thinking in their search for truth.

6. THE RIGHT TO DEVELOP POSITIVE, RESPONSIBLE AND CARING ATTITUDES AND BEHAVIORS TOWARD OTHERS and to recognize the rights of others to be safe and free from harassment and abuse.

8. THE RIGHT TO LEARN RESPONSIBILITY for themselves and their actions.

9. THE RIGHT TO MAKE RESPONSIBLE DECISIONS founded on religious conviction.

Summary

The unit deals with static charges and serves as an introduction to flowing charges in circuits. The content of the unit will extend to positive and negative charges, electric potential and fields, and interactions between charged bodies including charging by induction and conduction. Also addressed will be insulators and conductors.

Unit Goals

1. Students will understand concepts of charge, which include positive, negative, and neutral charge through laboratory experiences.
2. Students will understand how charge can be induced or conducted and the similarities and differences between conductors and insulators.
3. Students will understand how to use, apply, and explain electrical forces' relationship to distance and charge size and gain knowledge of how we use/see electrostatics in our everyday lives.

Big Ideas

1. Particles of matter have a property called charge which results in attractive and repulsive forces.

Enduring Understandings

1. Electric charge is conserved.
2. There is a fundamental electric charge. Positive electric charges are carried by protons, while negative electric charges are carried by electrons.
3. Charges result in attractive and repulsive forces.
4. Electric and magnetic forces obey the same inverse square law that governs gravitational interactions.
5. Electrostatic charge on an object, both positive and negative, is the result of the addition or removal of electrons only.

Content

1. For all methods of charging neutral objects, one object/system ends up with a surplus of positive charge and the other object/system ends up with the same amount of surplus of negative charge (conservation of charge).
2. Conductors have a lattice of fixed positively charged metal ions surrounded by a sea of negatively charged electrons that flow freely within the lattice.
3. When a charged object is near a neutral insulator, the electron cloud of each insulator atom shifts position slightly so it is no longer centered on the nucleus. The separation of charges for billions of neutral insulator particles can result in a net attractive force between the neutral insulator and the charged object.
4. The forces between point charges are proportional to the product of the charges and inversely proportional to the square of the distance between the point charges.
5. The strength of the electrical field of a charged object at a certain location is given by the electric force per unit charge experienced by another charged object placed at that location.
6. A single charge does not have electric potential energy. Only the system of attracting or repelling charges can have electric potential energy.

Skills

**Bloom's Taxonomy/DOK**

**Remember (Level 1)**

1. Use Coulombs Law to represent the relationship between electric force, charge, and distance of separation. Given information about the quantity of charge on two bodies and the separation distance, determine the electrostatic force acting on the bodies.
2. Recognize the similarities and differences between Coulombs Law and the Law of Universal Gravitation.
3. Recognize that an electric charge produces an electric field. Represent the electric field produced by point charges and charged plates.
4. Calculate the force exerted by a uniform electric field on a charged particle.
5. Draw parallels between the electric and gravitational fields.
6. Use the superposition principle to calculate the strength of the electric field produced by charge(s) at a given location.

**Understand (Levels 1 and 2)**

1. Distinguish between the two kinds of particles that are responsible for electric interactions.
2. Distinguish between conductors and insulators.

**Analyze (Level 3)**

1. Explain charging by conduction, induction, and polarization in terms of the movement of electrons.

**Evaluate (Levels 3 and 4)**

1. Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.

**Create (Level 4)**

1. Design experiments to find the relationships between quantifiable variables.
2. Create graphs from experimental data and derive mathematical relationships between variables (models).

Essential Questions

1. How does an object become charged?
2. What happens when charged objects interact with one another?
3. What happens when a charged object interacts with a neutral object?
4. What factors affect electrical forces between objects?
5. What is an electric field?
6. What determines the strength of an electric field?
7. What is electric potential energy? How is it measured?

Stage 2: Assessment Evidence

Introduction to Electrostatics Labs

Formative: Lab Assignment

Using a resource such as David Sokoloff's RealTime Physics Active Learning Laboratories: Module 3, Electricity Magnetism (Wiley) manual, students are introduced to electrostatics. The labs require very inexpensive materials and are highly regarded by physics teachers.

Electrostatic Charging Lab

Formative: Lab Assignment

This activity is designed to be done as a homework assignment. It is a very basic introduction to charging by friction, polarization, and the attraction and repulsion between charged objects and particles. Within the activity there are six multiple choice questions that are designed to be concept questions. Prior to assigning the activity, the students should be asked these questions that can be found in the link. Students are asked to vote on responses so the teacher can get a good idea of what they already know about the topic. After completing the activity the students should be able to answer all 6 concept questions correctly.

Coulomb's Law Lab

Formative: Lab Assignment

Students use the PhET website (see link below) to collect data to determine the relationship between electric charge size and force and charge separation distance and force. From graphs of the data, students should find that force is directly proportional to charge size and inversely proportional to the square of the distance separating them. Students should see the similarities between Newton's Law of Gravitation and Coulomb's Law.

Homework

Formative: Homework

Students may use readings, writings, questions and problems to reinforce concepts.

Quizzes

Formative: Quiz

Quizzes are used to gauge the progress of student understanding of learning content and skills.

Unit Test

Summative: Test

Students may take a Unit Test in order to demonstrate understanding.

Stage 3: Learning Plan

Learning Experiences

1. Guided Inquiry
2. Cooperative Learning Groups
3. Socratic Seminar
4. Small Group and Class Discussions
5. Direct Instruction
6. Critical Thinking

Technology Integration

1. SmartBoard
2. Smart phone
3. Computers Internet
4. Graphing software (Excel, LoggerPro)
5. Vernier software and hardware
6. Pasco software and hardware
7. Video analysis software

Resources

Resources

**Books**

1. O'Kuma,T. L., Maloney, D. P., Hieggelke, C. J. (2003). *Ranking task exercises in physics.* New York: Addison-Wesley.

**YouTube**

1. MinutePhysics videos provide concise and amusing explanations for many physics topics.

Resources

* The Physics Classroom (<http://www.physicsclassroom.com/>)

Grades 9-12 Science
Physics

DC Circuits

Stage 1: Desired Results

Catholic Standards

DOC All Grades DOC: Catholic Standards

The Profession of Faith

Students will be able to

1. Recognize God in the world's order, beauty, and goodness (CCC 32).

Life in Christ

Students will be able to

2. Know that we must assume responsibility for the acts we perform (CCC 1781).

7. Assume personal responsibility (CCC 1914).

12. Respect the integrity of all creation, including animals, plants, and all nature (CCC 2415).

Targeted Standards

NGSS Grade 9-12 NGSS: Crosscutting Concepts

Crosscutting Statements

Patterns Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

NGSS Grade 9-12 NGSS: Science and Engineering Practices

Practice 8. Obtaining, evaluating, and communicating information

Obtaining, evaluating, and communicating information in 912 builds on K8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.

Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Practice 6. Constructing explanations (for science) and designing solutions (for engineering)

Constructing explanations and designing solutions in 912 builds on K8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.

Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Practice 7. Engaging in argument from evidence

Engaging in argument from evidence in 912 builds on K8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.

Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Practice 1. Asking questions (for science) and defining problems (for engineering)

Asking questions and defining problems in 912 builds on K8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.

Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.

Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.

Ask questions to clarify and refine a model, an explanation, or an engineering problem.

Evaluate a question to determine if it is testable and relevant.

Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.

Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.

Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and/or environmental considerations.

Practice 2. Developing and using models

Modeling in 912 builds on K8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria.

Design a test of a model to ascertain its reliability.

Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.

Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Practice 3. Planning and carrying out investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigations design to ensure variables are controlled.

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.

Select appropriate tools to collect, record, analyze, and evaluate data.

Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.

Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

Practice 4. Analyzing and interpreting data

Analyzing data in 912 builds on K8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.

Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.

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Practice 5. Using mathematics and computational thinking

Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Apply techniques of algebra and functions to represent and solve scientific and engineering problems.

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Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).

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HS Physics

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Identify questions and concepts that guide scientific investigations;

Design and conduct scientific investigations;

Use technology and mathematics to improve investigations and communications;

Formulate and revise explanations and models using logic and evidence (critical thinking);

Recognize and analyze explanations and models

Communicate and defend a scientific argument.

Course Content: Electricity and magnetism

DC circuits: Ohms law

DC circuits: Series circuits

DC circuits: Parallel circuits

DC circuits: Mixed circuits

DC circuits: Applying conservation of charge and energy (junction and loop rules)

OH Grades 11-12 OH: Literacy in History/Social Studies, Science, & Technical Subjects 6-12

Writing

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WHST.11-12.1e. Provide a concluding statement or section that follows from or supports the argument presented.

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WHST.11-12.2d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.

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WHST.11-12.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

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Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.

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WHST.11-12.10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Reading: Science & Technical Subjects

Key Ideas and Details 1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

RST.11-12.1. Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.

RST.11-12.2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Analyze how and why individuals, events, or ideas develop and interact over the course of a text.

RST.11-12.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

Craft and Structure 4. Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

RST.11-12.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 1112 texts and topics.

Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole.

RST.11-12.5. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.

Assess how point of view or purpose shapes the content and style of a text.

RST.11-12.6. Analyze the authors purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.

Integration of Knowledge and Ideas 7. Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.

RST.11-12.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.

RST.11-12.8. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

RST.11-12.9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Read and comprehend complex literary and informational texts independently and proficiently.

RST.11-12.10. By the end of grade 12, read and comprehend science/technical texts in the grades 1112 text complexity band independently and proficiently.

Capacities of the Literate Individual

Students Who are College and Career Ready in Reading, Writing, Speaking, Listening, & Language

They demonstrate independence.

Catholic Identity

DOC All Grades Catholic Identity

Catholic Social Justice Teachings

Life and Dignity of the Human Person

Rights and Responsibilities

The Dignity of Work and the Rights of Workers

Call to Family, Community, and Participation

Option for the Poor and Vulnerable

Solidarity

Care for God's Creation

The Rights of Children

1. THE RIGHT TO A CATHOLIC COMMUNITY that witnesses to Christ and the Gospel by protecting them from child abuse, including sexual abuse and neglect.

2. THE RIGHT TO A SAFE ENVIRONMENT that promotes care, protection, and security.

3. THE RIGHT TO BE RESPECTED AS INDIVIDUALS with human dignity.

4. THE RIGHT TO WORK ACTIVELY TOWARD THEIR OWN EMPOWERMENT through the development of their gifts and talents.

5. THE RIGHT TO A LEARNING ENVIRONMENT THAT VALUES COOPERATION and challenges its members to critical and reflective thinking in their search for truth.

6. THE RIGHT TO DEVELOP POSITIVE, RESPONSIBLE AND CARING ATTITUDES AND BEHAVIORS TOWARD OTHERS and to recognize the rights of others to be safe and free from harassment and abuse.

8. THE RIGHT TO LEARN RESPONSIBILITY for themselves and their actions.

9. THE RIGHT TO MAKE RESPONSIBLE DECISIONS founded on religious conviction.

Summary

This unit attempts to connect circuits with electrostatics. Starting with the ideas that a separation of charge results in an electric field and in response to this field, mobile charge carriers move, students develop a more consistent model of circuits. The rate of charge flow (current) is emphasized as a *flow rate,* or quantity of charge moving through a cross-sectional area per unit time. Students develop a mathematical model for resistance by conducting an Ohm's Law Lab. Students also explore more complex circuits, containing two or more resistors in series and/or parallel arrangement. Safety devices such as fuses, circuit breakers and ground fault circuit interrupters are discussed.

Unit Goals

1. Students will understand why an electric current occurs.
2. Students will be able to measure an electric current and explain how voltage and resistance affect current.
3. Students will be able to differentiate between a series and parallel circuit and explain how the design of a circuit affects current and energy within the circuit.

Big Ideas

1. Electric fields cause charged particles to move, transferring energy stored in electricity to heat, light, sound and mechanical.

Enduring Understandings

1. Electricity is the movement of electrons within an electric field.
2. Electric currents transfer energy.

Content

1. The current is the same everywhere in a series circuit.
2. The equivalent resistance in a series circuit is the sum of the resistances of its parts.
3. The sum of the voltage drops across resistors in a circuit is equal to the potential difference applied across the combination.
4. The voltage drops across all branches of a parallel circuit are the same.
5. In a parallel circuit, the total current is equal to the sum of the currents in the branches.
6. The reciprocal of the equivalent resistance of parallel resistors is equal to the sum of the reciprocals of the individual resistances. If any branch of a parallel circuit is opened, there is no current in that branch. The current in the other branches is unchanged.
7. A complex circuit is often a combination of series and parallel branches. Any parallel branch is first reduced to a single equivalent resistance. Then any resistors in series are replaced with a single resistance.
8. A fuse, circuit breaker of GFCI, when placed in series with appliances, creates an open circuit when dangerously high currents flow.

Skills

**Bloom's Taxonomy/DOK**

**Remember (Level 1)**

1. Describe the concepts in an electrical circuit including electric potential energy,
electric potential, voltage, current, and resistance.
2. Use Ohms law (V = IR) to calculate circuit variables.
3. Identify the characteristics of simple series circuits including that the total resistance is equal to the sum of the resistances of the resistors (RT = R1 + R2 +...), the current is constant throughout the circuit, and the sum of the voltages across the resistors equals the voltage across the voltage source.
4. Identify the characteristics of simple parallel circuits including the inverse of the total resistance is equal to the sum of the inverses of the resistors (1/RT = 1/R1 +1/R2...), the voltage across each resistor is the same as the voltage source, and the sum of the currents in the branches equals the current output by the voltage source.
5. Describe short circuits and the function of circuit breakers.

**Understand (Levels 1 and 2)**

1. Select appropriate tools to collect, record, analyze, and evaluate data.

**Analyze (Level 3)**

1. Explain that current is not used up in an electric circuit; rather, the electric potential energy of a charge is converted to heat energy as the charge flows through a resistor.
2. Explain why houses are wired in parallel.

**Evaluate (Levels 3 and 4)**

1. Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

**Create (Level 4)**

1. Design experiments to find the relationships between quantifiable variables.
2. Create graphs from experimental data and derive mathematical relationships between variables (models).

Design and conduct scientific investigations.

Essential Questions

1. What is an electric current?
2. How do you measure electric current?
3. What factors affect electric current?
4. What is an electric circuit?
5. How does electricity transfer energy?
6. How does circuit design affect electric current and energy?

Stage 2: Assessment Evidence

Teacher Directed Reading

Formative: Reading Task

Teacher assigns reading appropriate to unit, which may come from textbook or sources such as Scientific American articles from Ebsco Host through INFOhio.

In-Class Work

Formative: Cooperative Group Work

Students may work in groups on tasks; application of new equations is especially aided by working in groups.

KWL Chart

Diagnostic: Self Assessment

Before beginning a unit, students discuss what they already know about the topic and what they expect to learn.

Unit Test

Summative: Test

Teacher designed, unit-appropriate tests may be given at the end of the unit.

Virtual Circuits Lab

Formative: Lab Assignment

If you do not have enough equipment to do a hands on circuit lab but have a computer lab available, this site will be helpful for a virtual lab.

Series and Parallel Lab

Formative: Lab Assignment

This exercise is from Phyzlab, a good starter lab for exploration of the two types of circuits. You will need batteries, bulbs, and wires.

Open and Short Circuits Lab

Formative: Lab Assignment

In another activity from Phyzlab, students discover the difference between an open circuit and short circuit. Your students will need wires, batteries, bulb, and an ammeter or multimeter.

Homework

Formative: Homework

Students may complete readings, writings, questions and problems in order to practice concepts.

Stage 3: Learning Plan

Learning Experiences

1. Guided Inquiry
2. Cooperative Learning Groups
3. Socratic Seminar
4. Small Group and Class Discussions
5. Direct Instruction
6. Critical Thinking

Technology Integration

1. SmartBoard
2. Smart phone
3. Computers Internet
4. Graphing software (Excel, LoggerPro)
5. Vernier software and hardware
6. Pasco software and hardware
7. Video analysis software

Resources

Resources

**Books**

1. O'Kuma,T. L., Maloney, D. P., Hieggelke, C. J. (2003). *Ranking task exercises in physics.* New York: Addison-Wesley.

**YouTube**

1. MinutePhysics videos provide concise and amusing explanations for many physics topics.

Resources

* The Physics Classroom (<http://www.physicsclassroom.com/>)

Grades 9-12 Science
Physics

Electromagnetism

Stage 1: Desired Results

Catholic Standards

DOC All Grades DOC: Catholic Standards

The Profession of Faith

Students will be able to

1. Recognize God in the world's order, beauty, and goodness (CCC 32).

Life in Christ

Students will be able to

2. Know that we must assume responsibility for the acts we perform (CCC 1781).

7. Assume personal responsibility (CCC 1914).

12. Respect the integrity of all creation, including animals, plants, and all nature (CCC 2415).

Targeted Standards

NGSS Grade 2 NGSS: Disciplinary Core Ideas

ETS1: Engineering Design

Defining and Delimiting an Engineering Problem

A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. (K-2-ETS1- 1) (secondary to KPS2-2)

NGSS Grade 9-12 NGSS: Crosscutting Concepts

Crosscutting Statements

Patterns Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

NGSS Grade 9-12 NGSS: Science and Engineering Practices

Practice 8. Obtaining, evaluating, and communicating information

Obtaining, evaluating, and communicating information in 912 builds on K8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.

Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Practice 6. Constructing explanations (for science) and designing solutions (for engineering)

Constructing explanations and designing solutions in 912 builds on K8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.

Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Practice 7. Engaging in argument from evidence

Engaging in argument from evidence in 912 builds on K8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.

Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Practice 1. Asking questions (for science) and defining problems (for engineering)

Asking questions and defining problems in 912 builds on K8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.

Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.

Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.

Ask questions to clarify and refine a model, an explanation, or an engineering problem.

Evaluate a question to determine if it is testable and relevant.

Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.

Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.

Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and/or environmental considerations.

Practice 2. Developing and using models

Modeling in 912 builds on K8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria.

Design a test of a model to ascertain its reliability.

Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.

Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Practice 3. Planning and carrying out investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigations design to ensure variables are controlled.

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.

Select appropriate tools to collect, record, analyze, and evaluate data.

Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.

Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

Practice 4. Analyzing and interpreting data

Analyzing data in 912 builds on K8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.

Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.

Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.

Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.

Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Practice 5. Using mathematics and computational thinking

Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Apply techniques of algebra and functions to represent and solve scientific and engineering problems.

Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model makes sense by comparing the outcomes with what is known about the real world.

Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).

OH Grade 9-12 OH: Science (2011)

HS Physics

Science Inquiry and Application During the years of grades 9 through 12 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

Identify questions and concepts that guide scientific investigations;

Design and conduct scientific investigations;

Use technology and mathematics to improve investigations and communications;

Formulate and revise explanations and models using logic and evidence (critical thinking);

Recognize and analyze explanations and models

Communicate and defend a scientific argument.

Course Content: Electricity and magnetism

Magnetic fields and energy

Electromagnetic interactions

OH Grades 11-12 OH: Literacy in History/Social Studies, Science, & Technical Subjects 6-12

Writing

Text Types and Purposes 1. Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence.

WHST.11-12.1. Write arguments focused on discipline-specific content.

WHST.11-12.1a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.

WHST.11-12.1b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audiences knowledge level, concerns, values, and possible biases.

WHST.11-12.1c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.

WHST.11-12.1d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

WHST.11-12.1e. Provide a concluding statement or section that follows from or supports the argument presented.

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

WHST.11-12.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

WHST.11-12.2a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.

WHST.11-12.2b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audiences knowledge of the topic.

WHST.11-12.2c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.

WHST.11-12.2d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.

WHST.11-12.2e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).

Production and Distribution of Writing 4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

WHST.11-12.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.

WHST.11-12.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

WHST.11-12.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

Research to Build and Present Knowledge 7. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

WHST.11-12.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.

WHST.11-12.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

Draw evidence from literary or informational texts to support analysis, reflection, and research.

WHST.11-12.9. Draw evidence from informational texts to support analysis, reflection, and research.

Range of Writing 10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

WHST.11-12.10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Reading: Science & Technical Subjects

Key Ideas and Details 1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

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Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.

RST.11-12.2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Analyze how and why individuals, events, or ideas develop and interact over the course of a text.

RST.11-12.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

Craft and Structure 4. Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

RST.11-12.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 1112 texts and topics.

Assess how point of view or purpose shapes the content and style of a text.

RST.11-12.6. Analyze the authors purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.

Integration of Knowledge and Ideas 7. Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.

RST.11-12.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.

RST.11-12.8. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

RST.11-12.9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Capacities of the Literate Individual

Students Who are College and Career Ready in Reading, Writing, Speaking, Listening, & Language

They demonstrate independence.

Catholic Identity

DOC All Grades Catholic Identity

Catholic Social Justice Teachings

Life and Dignity of the Human Person

Rights and Responsibilities

The Dignity of Work and the Rights of Workers

Call to Family, Community, and Participation

Option for the Poor and Vulnerable

Solidarity

Care for God's Creation

The Rights of Children

1. THE RIGHT TO A CATHOLIC COMMUNITY that witnesses to Christ and the Gospel by protecting them from child abuse, including sexual abuse and neglect.

2. THE RIGHT TO A SAFE ENVIRONMENT that promotes care, protection, and security.

3. THE RIGHT TO BE RESPECTED AS INDIVIDUALS with human dignity.

4. THE RIGHT TO WORK ACTIVELY TOWARD THEIR OWN EMPOWERMENT through the development of their gifts and talents.

5. THE RIGHT TO A LEARNING ENVIRONMENT THAT VALUES COOPERATION and challenges its members to critical and reflective thinking in their search for truth.

6. THE RIGHT TO DEVELOP POSITIVE, RESPONSIBLE AND CARING ATTITUDES AND BEHAVIORS TOWARD OTHERS and to recognize the rights of others to be safe and free from harassment and abuse.

7. THE RIGHT TO LEARN THE SKILL OF SELF PROTECTION by identifying safe and unsafe situations.

9. THE RIGHT TO MAKE RESPONSIBLE DECISIONS founded on religious conviction.

Summary

The basic idea introduced is the induction of electrical current production by moving conductors in a magnetic field. An understanding of alternating current generators involves the concepts of effective and maximum currents.

Unit Goals

1. Students will understand how electric motors and generators work.
2. Students will understand how electromagnets work.
3. Students will understand how magnetic fields and electrical fields interact.
4. Students will understand how the strength of a magnet affects the field around it.
5. Students will understand the direction of force exerted by a magnetic field on a moving particle.

Big Ideas

1. Changing magnetic fields causes charged particles to move.
2. Electric and magnetic phenomena are related and have many practical applications.

Enduring Understandings

1. Magnets have force fields similar to electric and gravitational fields.
2. Magnetic fields are created by permanent magnets or by electrical currents.
3. Electromagnetism is the interaction between an electric field and a magnetic field.
4. Magnetic materials and electric currents (moving electric charges) are sources of magnetic fields and are subject to forces arising from the magnetic fields of other sources.
5. Changing magnetic fields produces electric fields, thereby inducing currents in nearby conductors.
6. Electrical currents and magnetic fields interact to power electric motors or generate electric power.

Content

1. When a current-carrying wire is placed in a magnetic field, there is a force on the wire that is perpendicular to the field and also to the wire.
2. The strength of a magnetic field is measured in Teslas.
3. An electric motor consists of a coil of wire placed in a magnetic field. When current flows in the coil, the coil rotates due to the force on the wire in the magnetic field.
4. The force a magnetic field exerts on a charged particle depends on the velocity of the particle and the strength of the field and is in a direction perpendicular to both.
5. An electric generator consists of a number of wire loops placed in a magnetic field. Because each side of the coil moves alternately up and down through the field, the current alternates direction through the loops. The generator develops alternating voltage and current.
6. A generator and a motor are similar devices. A generator converts mechanical energy to electric energy; a motor converts electric energy to mechanical energy.

Skills

**Bloom's Taxonomy/DOK**

**Remember (Level 1)**

1. Identify questions and concepts that guide scientific investigations.

**Understand (Levels 1 and 2)**

1. Describe an electromagnet.
2. Describe how magnetic fields and electric fields interact.
3. Describe how the strength of the magnet affects the field around it.
4. Deduce in what direction the force is exerted by a magnetic field on a moving particle.

**Analyze (Level 3)**

1. Differentiate between an electric motor and an electric generator.

**Evaluate (Levels 3 and 4)**

1. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.
2. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

Evaluate a question to determine if it is testable and relevant.

**Create (Level 4)**

1. Construct an electromagnet.
2. Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Essential Questions

1. What is an electric charge and how does it relate to magnetism?
2. How do electric motors and generators work?
3. How do electromagnets work?
4. How do magnetic fields and electric fields interact?
5. How does the strength of the magnet affect the field around it?
6. In what direction is the force exerted by a magnetic field on a moving particle?
7. How is alternating current produced?
8. How is current induced in a magnetic field?

Stage 2: Assessment Evidence

KWL Chart

Diagnostic: Self Assessment

Before beginning a unit, students discuss what they already know about the topic and what they expect to learn.

Two Labs: A Solenoid and an Electromagnet

Formative: Lab Assignment

The attached link contains two basic labs, one making a solenoid and one making an electromagnet with easily found materials.

Moving with Magnets

Summative: Lab Assignment

Students will propel a small car using bar magnets. Given the tools, they will apply the concepts learned in the unit.

Teacher Directed Reading

Formative: Reading Task

Teacher assigns reading appropriate to unit, which may come from textbook or from a source such as Scientific American articles from Ebsco Host through INFOhio.

In-Class Work

Formative: Cooperative Group Work

Working in groups on tasks is especially helpful when students apply new equations.

Unit Test

Summative: Test

Teacher designed, unit-appropriate tests may be given at the end of the unit.

Homework

Formative: Homework

Students may complete readings, writings, questions and problems to practice concepts.

Stage 3: Learning Plan

Learning Experiences

1. Guided Inquiry
2. Cooperative Learning Groups
3. Socratic Seminar
4. Small Group and Class Discussions
5. Direct Instruction
6. Critical Thinking

Technology Integration

1. SmartBoard
2. Smart phone
3. Computers Internet
4. Graphing software (Excel, LoggerPro)
5. Vernier software and hardware
6. Pasco software and hardware
7. Video analysis software

Resources

Resources

**Books**

1. O'Kuma,T. L., Maloney, D. P., Hieggelke, C. J. (2003). *Ranking task exercises in physics.* New York: Addison-Wesley.

**YouTube**

1. MinutePhysics videos provide concise and amusing explanations for many physics topics.

Resources

* The Physics Classroom (<http://www.physicsclassroom.com>)